ZETRON

Model 1730 Controller
Model 1732 RTU
Technical Manual

Part No. 025-9406D.1

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1. This device complies with Part 68 of the FCC rules. The FCC registration number of this device, the ringer equivalence number and the connection jack type RJ11C, if requested, must be reported to the telephone company. The FCC registration number and the ringer equivalence number may be found on the label attached to the device.

2. The ringer equivalence number (REN) is used to determine the quantity of devices which may be connected to the telephone line. Excessive RENs on the telephone line may result in the devices not ringing in response to an incoming call. The sum of ringer equivalence numbers for all devices connected to a single telephone line should not exceed five (5.0) for reliable operation. To be certain of the number of devices that may be connected to a line, as determined by the total RENs, contact the local telephone company.

3. If this device causes harm to the telephone network, the telephone company will notify you in advance that temporary discontinuance of service may be required. If advance notice is not practical, the telephone company will notify you as soon as possible. You will also be advised of your right to file a complaint with the FCC if you believe it is necessary.

4. The telephone company may make changes in its facilities, equipment, operations or procedures that could affect the operation of this equipment. If this happens, the telephone company will provide advance notice in order for you to make necessary modifications to maintain uninterrupted service.

5. This device must not be installed on coin-operated telephone lines or party lines.

6. Repair work on this device must be done by Zetron, Inc. or a Zetron authorized repair station. If this device is causing harm to the telephone network the telephone company may request that you disconnect the equipment until the problem is resolved.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his or her own expense.

Changes or modifications not expressly approved by the manager of Zetron's compliance department can void the FCC authorization to operate this equipment.

INDUSTRY CANADA REGISTRATION

NOTICE: The Industry Canada label identifies certified equipment. This certification means that the equipment meets certain telecommunications network protective, operational and safety requirements as prescribed in the appropriate Terminal Equipment Technical Requirements document(s). The Department does not guarantee the equipment will operate to the user's satisfaction.

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. The customer should be aware that compliance with the above conditions may not prevent degradation of service in some situations.

Repairs to certified equipment should be coordinated by a representative designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

Users should ensure for their own protection that the electrical ground connections of the power utility, telephone lines and internal metallic water pipe system, if present, are connected together. This precaution may be particularly important in rural areas.

CAUTION: Users should not attempt to make such connections themselves, but should contact the appropriate electric inspection authority, or electrician, as appropriate.

NOTICE: The **Ringer Equivalence Number** (REN) assigned to each terminal device provides an indication of the maximum number of terminals allowed to be connected to a telephone interface. The termination on an interface may consist of any combination of devices subject only to the requirement that the sum of the Ringer Equivalence Numbers of all the devices does not exceed 5.

CANADIAN EMC COMPLIANCE NOTICE

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

AVIS CANADIEN

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

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INTRODUCTION

The Model 1730 Controller and the Model 1732 RTU are the primary hardware components of a Supervisory Control and Data Acquisition (SCADA) system. A SCADA system is used to monitor and control equipment and processes and retrieve information from remote sites.

A typical SCADA system consists of three major elements:

1. Data acquisition and control devices at remote sites
2. A communications system
3. Control software, often run on a PC

The Model 1732 remote terminal units (RTUs) at remote sites obtain data via input connections and control processes via output connections. The Model 1730 controller may also have input and output connections to acquire local data and control local processes. The controller and RTU along with the radio and telephone links make up the communications system of a SCADA system (see Figure 1).

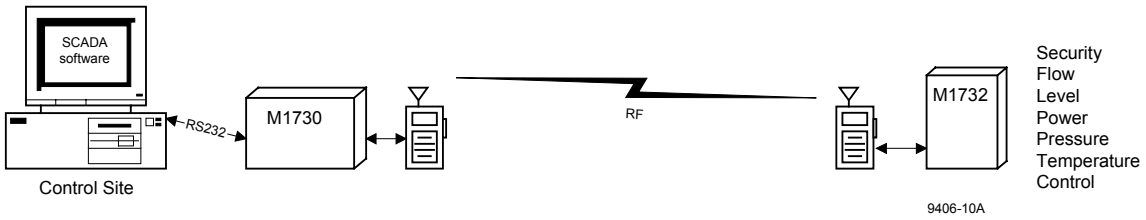


Figure 1. A Simplified SCADA System with Model 1730 Controller and Model 1732 RTU

To control a SCADA system, special software is required. The Model 1730 and Model 1732 are compatible either with a SCADA program or programmable logic controller (PLC) using the industry-standard MODBUS protocol (e.g., Lookout™). The SCADA program is the brains of the system and allows the operator to monitor, control, display, log, and print system data.

MODBUS SYSTEM

MODBUS is an industry-standard protocol used to transfer commands and data. An example of a SCADA program that uses the MODBUS protocol is Lookout (by National Instruments). Many PLCs also use the MODBUS protocol. A MODBUS option for the Model 1730 controller allows the controller and Zetron RTUs to be used in a MODBUS system.

A MODBUS SCADA system with a Model 1730 controller is shown in Figure 2.

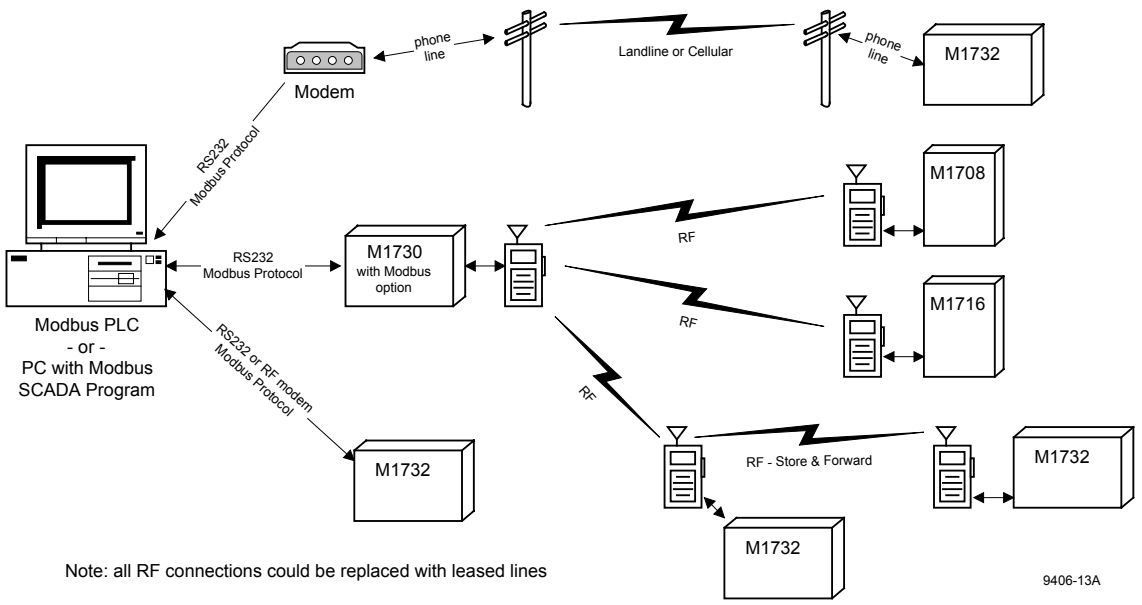


Figure 2. Generalized MODBUS System

In a MODBUS system, the PC can communicate with up to 150 Model 1732, Model 1708 or Model 1716 RTUs over radio or wireline through a single Model 1730 controller. A system can be expanded beyond 150 RTUs by adding additional controllers and using additional serial ports on the PC. The total number of RTUs in a system is limited only by the number of serial ports available on the PC, and by the MODBUS slave address limit of 247.

DEVICES

The Model 1730/1732 devices consist of an enclosure/box containing a core module and a customer-specified number and type of other modules. In addition to the core module, there are the following modules:

- Digital I/O
- Relay Output
- Analog Input
- Analog Output
- Radio Interface (also called radio modem)
- Phone Modem (not used in controllers)
- AC Power
- Battery Charger

The modularity of the devices allows the system size to be closely tailored to fit the number of inputs and outputs at each site. If the I/O points at a site change, modules are easily added or removed to meet the new requirements.

Controller

The Model 1730 controller controls many RTUs from a central site. The purpose of the controller is to provide an interface between the SCADA program or PLC and the inputs and outputs on the RTUs and on the controller itself. It communicates with the RTUs over radio links, and it communicates with the PC running the SCADA program using an RS-232 link.

The controller I/O configuration is very flexible and can be easily changed to meet the needs of the central site.

The basic functions of the Model 1730 are listed below:

- Expandable local inputs and outputs (up to a total of 32 I/O modules, up to 16 of any single module type)
- Supports all types of Model 1730/1732 I/O modules
- Derived I/O similar to Model 1708/Model 1716 (accumulators, counters, etc.)
- Device software (firmware) field upgradable

Remote Terminal Unit (RTU)

The Model 1732 RTU provides status of inputs and control of outputs to the controller or directly to the PC running the SCADA program. The RTU transmits data to the controller by polling or by exception reporting. It communicates using either phone modem, radio, or direct RS-232.

The I/O configuration of the RTU is very flexible and can be easily changed to meet the needs for each site. Expansion in the field is accomplished by adding I/O modules.

The RTU local logic provides local control independent of the PC and/or controller. This local logic can take over in case of communication failure or it can be active at all times.

A data logging system collects data from many input or output points. A flexible method to turn on and off the data logging is provided by using wizards in the Configuration Utility to create local logic programs.

The basic functions of the Model 1732 RTU are as follows:

- Store and forward for RTU radio transmissions
- Allows either phone or radio communications with the PC
- Supports MODBUS protocol through RS-232 port for direct or phone modem connection to MODBUS SCADA software
- Supports polling and reporting by exception
- Expandable I/O. When communicating over radio with a Model 1730 Controller in a MODBUS system, the RTU may have up to 16 I/O modules. In other types systems, it may have up to 32 I/O modules, and up to 16 of any one type of module.
- Supports all types of Model 1730/1732 I/O modules
- Derived I/O similar to Model 1708/Model 1716 (accumulators, counters, etc.)
- User programmable local logic

Data logging provided by the core module's battery-backed RAM. Data can be logged and stored for retrieval by the Configuration Utility. This data is useful for troubleshooting.

Device software (firmware) may be upgraded in the field

USING THIS MANUAL

This manual is for SCADA system integrators, installation technicians, and service technicians.

Before installing the controller and RTUs, read “OPERATION” section (stating on page 7) to understand the functioning of the Model 1730 and Model 1732. The “OPERATION” section describes the operation of the controller and RTUs in a MODBUS system. If your system is controlled by a MODBUS program, be sure to read the “MODBUS SYSTEM” section (starting on page 15), which has information specific to MODBUS systems.

To install and set up the system, follow the instructions in the “INSTALLATION” section, starting on page 29. For troubleshooting and maintenance information, see “MAINTENANCE AND TROUBLESHOOTING”, starting on page 47. For detailed information about the nine modules, see “MODULES”, starting on page 55.

The appendices include:

A. Dimensions for mounting the devices

B. Instructions for the Communications & I/O Test Program

C. Glossary

SPECIFICATIONS

ENVIRONMENTAL

Temperature 0°C to 50°C

Humidity to 95% non condensing

HARDWARE SPECIFICATIONS

Maximum number of I/O points per device: 445

Real Time Clock Accuracy

At 25°C:	±55 ppm
From –10°C to 70°C:	+10/–120 ppm
(At room temp.:	±5 seconds/day)

For individual module specifications, see the “MODULES” section starting on page 55.

ENCLOSURE DIMENSIONS

Zetron Box:	12 x 6.5 x 5.5 inches
Medium NEMA enclosure:	16 x 14 x 6 inches
Large NEMA enclosure:	24 x 20 x 8 inches

FUNCTIONAL SPECIFICATIONS

Speed of Monitoring/Control/Local Logic

The Model 1732 RTU functions with a 1-second monitor period. It looks at all inputs and updates all outputs once per second.

Extremely complicated local logic may delay the processing. In this case, the monitor and control function begins again at the next 1-second period. The local logic has an input indicating whether or not the 1-second update period has been exceeded. This input can be used in the local logic to take action if the logic takes longer than 1 second to process.

OPERATION

When your SCADA system is set up and working, the Model 1730 controller and Model 1732 RTU operate automatically or as directed by a human operator at the PC running your SCADA program (a MODBUS protocol SCADA program).

Before installing the Controller and RTUs, read this section to understand the functioning of the Model 1730 and Model 1732. This section describes how the controller and RTUs operate in MODBUS systems. If your system is controlled by a MODBUS program, be sure to read the next section (starting on page 15), which has information specific to MODBUS systems.

For more detailed information about operating your SCADA program, please see your SCADA program documentation.

COMMUNICATIONS

Channels

The controller and RTUs make up the communications system of the SCADA system. The PC running the ULTRAc.W/MODBUS program is the "master." The master queries the input/output points via the communications system.

The communication path between the SCADA program running on a PC and the Model 1730 controller is by a direct RS-232 connection. The path between the PC and the Model 1732 RTU is either indirect by radio and/or wireline through the Model 1730 controller, or direct to the Model 1732 RTU by serial connection or by phone modem. The Model 1730 controller also allows the PC to communicate indirectly with Zetron's Model 1708 and Model 1716 RTUs over radio or wireline.

The controller and RTUs cannot communicate without the SCADA program.

Data Communications

There are two ways to set up automatic communications: polled only or exception reporting.

Polled-Only

In a polled-only system the master controls all communication in the system. The RTUs only transmit in response to a poll (query).

Exception Reporting

Exception reporting is the ability of the controller or RTU to report changes in I/O status asynchronously to the SCADA program or controller. The device reports changes in I/O status as they occur without waiting to be polled.

Exception reporting can be enabled or disabled globally for the entire device and individually enabled for each I/O point.

For the Model 1730 controller, exception reporting is always through the RS-232 serial port.

For the RTU, exceptions can be reported via the radio, phone, or direct RS-232 connection. The RTU configuration includes a setting that tells which method to use for exception reporting. The Model 1732 does not support exception reporting over more than one channel at a time.

Retries are controlled by several settings that specify the number of attempts and the interval between attempts. The interval between attempts can be either fixed at a set value, or can be set up to increase in small random increments on each attempt until it reaches some maximum value.

Communications Failures

The controller and RTUs monitor inter-device communications in three areas:

1. Exception reporting
2. Polling
3. RS-232 Watchdog

The communications modes and communications failure actions are set using the Configuration Utility.

Exception Reporting Communications Failures

When the Model 1730/1732 has attempted to send an exception report the programmed number of retries without a response, a communications failure occurs. A controller can be configured so that a communications failure forces all its outputs to their default state (digital outputs and relays turned off, and analog outputs set to zero) or turns on the core module relay output 5. An RTU can be configured so that a communications failure starts a local logic program.

The communications failure is cleared when communications are re-established. Communications are re-established when the SCADA program acknowledges the communications failure exception report.

Polling Communications Failures

When an RTU does not receive a poll because communications are broken or the SCADA program has failed, another type of communications failure occurs. Using a local logic program, an RTU can be configured so that when it is not polled for a programmed period of time, it can perform programmed tasks. The local logic program uses a built-in variable, LastPollTime, to detect this type of communications failure.

RS-232 Watchdog Communications Failures

To alert the system operator in case the PC breaks down, the controller RS-232 watchdog function allows the controller to turn on an output if the PC stops sending messages. The output is usually wired to an alarm device like a buzzer or autodialer.

Store and Forward

Sometimes a controller and RTU are out of radio range of each other, but are both within range of an intermediate RTU. As shown in Figure 3, they can communicate indirectly using the store and forward function of the intermediate RTU.

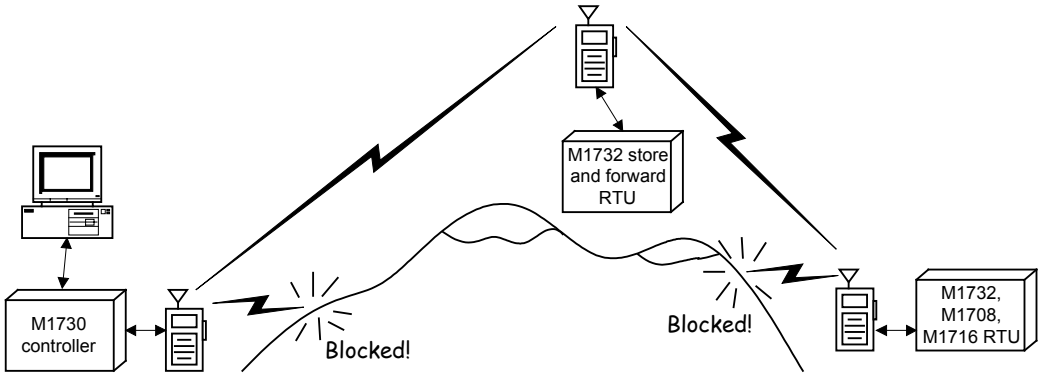


Figure 3. Store and Forward Communications

The intermediate RTU receives all messages transmitted by either the controller or the distant RTU. When it receives a message, it looks in its store and forward table to see if the message should be forwarded. If so, it replaces the addresses in the message and re-transmits it.

For further information about this function, see “RADIO INTERFACE MODULE” on page 69.

All Call and Group Call Addresses

The all call and group call addresses in the RTU provide a way for the SCADA program to send a control command over radio to several RTUs at the same time.

When an RTU receives a command over radio, it checks to see if the command was sent to its own address, to its all call address, or to its group call address. If it was sent to its all call or group call address, the RTU executes the command, but it does not generate a response. Because no response is sent back to the SCADA program, the all call and group call addresses are useful for output control commands, but they are not useful for status polling.

The all call and group call addresses are set using the Configuration Utility.

INPUTS AND OUTPUTS

Core Module I/O

The Model 1730/1732 core module has eight digital inputs and five digital outputs.

Outputs 1 through 4 are open-collector relay drivers. They provide an open circuit voltage when turned off, and they provide ground when turned on. Output 5 is a form C relay.

The core digital inputs have the ability to count pulses and keep track of run time. The digital inputs have a weak pull up to the power supply.

Digital I/O Modules

Each of the 16 input/output points on a digital I/O module can be configured as either an input or output through the Configuration Utility. By default, all are configured as inputs.

The outputs on the digital I/O module are open-collector relay drivers with a pull-up resistor to the power supply voltage. They provide the power supply voltage when turned off, and they provide ground when turned on.

Relay Output Modules

Each relay output module has six form C relay outputs.

Analog Input Modules

Usually analog inputs are used with transducers that convert a real world value into a voltage in the range of 0 to 5 V or –10 to +10 V or into a current in the range of 4 to 20 mA.

There are 11 inputs on each analog input module. Each input can measure either voltage or, with a jumper installed on the module's PCB, current.

Analog Output Modules

There are four outputs on each analog output module. Each output provides both voltage (0 V to 4.980 V) and current (0 mA to 19.92 mA) connections.

Accumulators, Counters, and Run-Times

Analog input accumulators keep a running total of the analog input value over a period of time. Accumulators are normally used for flow measurements. If an analog input is measuring flow rate (e.g., gallons per minute), the corresponding accumulator shows total flow (in gallons). There are 11 accumulators, one for each input of the analog input module with address 0. Accumulators are not supported for analog input modules with addresses 1 to 15.

If the sensor connected to the analog input has a maximum absolute output of 10V or 40 mA, the accumulator will run for at least 12 days before overflowing. If the sensor has a

maximum absolute output of 5V or 20 mA, the accumulator will run for at least 24 days without overflowing.

A digital input counter value is the number of pulses detected on the input during a measurement period. Digital input counters are also used to measure things such as flow. There are eight counters, one for each digital input on the core module. The first five counters will accept high-speed signals of up to 1000 cycles per second. The three remaining counters will accept only low speed signals of 0.5 cycles per second or slower.

The maximum number of pulses the counter can hold is 2,147,483,647 pulses. If the counter is fed pulses at the fastest rate possible (1000 pulses per second), it will operate for 24 days before the counter overflows.

A digital input run-time value is the total amount of time (in seconds) that the input was active during a measurement period. Digital input run-times are used to measure things such as the length of time a pump is on. There are eight run-times, one for each digital input on the core module.

The maximum run time available is 2,147,483,647 seconds, or about 68 years.

RTU SPECIAL FUNCTIONS

Local Logic

Local logic is a built-in function of the Model 1732 RTU. This function allows logic to be performed at the RTU independently from the PC. The logic can function with inputs and outputs at the RTU as well as some status indicators, such as communication failure.

Examples of local logic programs include pump rotation and data logging start-stop. Another possible use is for the local logic program to let the SCADA program control the RTU under normal conditions but to switch to local logic when a communications failure is detected.

The Configuration Utility provides the editor and compiler for local logic programs. Wizards in the Configuration Utility allow the user to generate simple control programs without having to learn the implementation details of the local logic. See the *RTU Configuration Utility User's Manual* (Part No. 025-9445) for more information.

Data Logger

Data logging is a method for capturing data on the inputs and outputs of an RTU so changes can be analyzed and perhaps recreated. It is used for troubleshooting by gathering data surrounding a trouble event or for capturing critical data when a communications failure occurs.

The RTU can be used as a simple, flexible, data acquisition system by using the data logging function along with the local logic to start and stop the data logging. Data logging is limited

to changes in input and output status. Other items such as power up/down conditions, errors, etc. are not logged.

Individual inputs and outputs are enabled for data logging using the Configuration Utility. To use the data logging function, a local logic program must be written (using the wizard in the Configuration Utility is an easy way to create the local logic program). Then the local logic program starts and stops data logging.

When the local logic program starts data logging, the current status of all logging enabled I/O points is stored in the log. Then whenever the inputs or outputs change, the changes are logged.

Analog inputs and outputs can be individually configured to specify how much of a change is logged. Any condition that causes an exception report on an I/O point also can cause the point to be logged. In other words, the conditions for reporting an exception and the conditions for logging a change are the same.

See the *RTU Configuration Utility User's Manual* (Part No. 025-9445) for more information.

Logging Control

Logging, as a whole, is started or stopped only through statements in the RTU local logic. It can be started or stopped based on conditions such as communications failure, time of day, condition of an input, etc. Logging for each individual I/O point is enabled or disabled using the device configuration part of the Configuration Utility.

Data Retrieval

The logged data is not automatically sent out of the Model 1732 RTU, but must be retrieved using the Configuration Utility (the MODBUS program cannot retrieve the data).

The data is retrieved via direct RS-232, phone modem, or radio interface. The Configuration Utility extracts the data and saves it to a text file. The data in the text file is comma delimited. The data may be imported into many spreadsheet and database programs for further analysis. The Configuration Utility also is used to clear the data logger records.

Record Contents

Each record in the data logger buffer includes the following information:

- Time stamp Includes date and time (to 1 second) that the data was logged
- Type of I/O point Digital input, analog output, etc.
- Module address (if applicable)
- I/O number
- Value

Real Time Clock

The data logging function uses the real time clock in the RTU to put a time and date stamp on each logged item. The real time clock is set in an RTU using the Configuration Utility.

Storage Capacity

The Model 1732 RTU data logger uses a portion of the battery-backed RAM on the core module CPU circuit board.

The buffer for the data logger is 32,000 bytes long. The maximum number of records that can be stored depends on the type of data being logged. A rough estimate is eight bytes per record, thus resulting in a capacity of approximately 4000 records.

Data Logger Buffer Status

The status of the data logger buffer can be retrieved from the RTU using the Configuration Utility. The status reported contains the amount of memory used up by logged data.

The data logger buffer must be retrieved from the RTU. It cannot be reported by exception.

Buffer Overflow

The RTU handles overflow of the data logger buffer in one of two ways:

- It can retain the current contents of the buffer and ignore all new data (which will be lost).
- It can store the new data by overwriting the oldest data in the buffer (the overwritten data will be lost).

MODBUS SYSTEM

This section describes the functioning of the Model 1730 controller and Model 1732 RTU in a MODBUS system. It also includes information about Zetron's Model 1708/1716 RTUs, which may be included in a MODBUS system when used with a Model 1730 controller.

MODBUS OPTION

The Model 1730 controller has an optional implementation of the industry standard MODBUS protocol. The Model 1732 RTU includes the MODBUS implementation as a standard function. The MODBUS implementation makes the devices compatible with nearly all SCADA programs as well as with many PLCs.

The Model 1730/1732 is compatible with most MODBUS programs that use five-digit MODBUS addresses and limit themselves to the functions listed in Table 1.

Table 1. Compatible MODBUS Functions

MODBUS Function	Function Code	Used for...
Read Coil Status	01	Digital outputs, relay outputs, and digital I/O configured as outputs
Force Single Coil	05	
Force Multiple Coils	15	
Read Input Status	02	Digital inputs and digital I/O configured as inputs
Read Holding Registers	03	Analog outputs, accumulators, counters, and run-times, RTUBASIC register variables
Preset Single Register	06	
Preset Multiple Registers	16	
Read Input Registers	04	Analog inputs

The correspondence between Zetron and MODBUS I/O terminology is listed in Table 2.

Table 2. Zetron and MODBUS I/O Terminology

Zetron I/O Type	MODBUS I/O Type
Digital/Relay Output	Coil
Digital Input	Input Status
Analog Input	Input Register
Analog Output	Holding Register
Accumulator	Holding Register
Counter	Holding Register
Run-time	Holding Register
RTUBASIC Register	Holding Register

COMMUNICATIONS

In a MODBUS system using radio or wireline communications, only the controller speaks MODBUS. For queries addressed to RTUs, the controller translates back and forth between the MODBUS protocol and the RTU radio protocol.

Storage of RTU Status in Controller (Radio Only)

To implement the equivalent of exception reporting and to speed up communications with the PC and reduce the amount of air time used by the system, the Model 1730 controller has the ability to respond to queries from the PC with RTU status information stored within its own memory. When the PC sends a query to an RTU through the Model 1730 controller, the controller responds immediately with its stored status for the RTU. A radio transmission occurs only if the controller does not have the RTU status requested or if the PC tries to control an RTU output.

Two mechanisms allow the Model 1730 controller to keep the locally stored RTU status up to date. One way is to set up the controller to poll the RTUs in the system periodically. This allows the PC to poll at a high rate while the Model 1730 controller polls the RTUs over the radio channel at a much slower rate. The other way is to set up the RTUs for exception reporting, causing the controller's RTU status storage to be updated.

Generally, a system is configured so that the controller polls the RTUs at a very slow rate — perhaps once per hour or less often, depending on the application. These polls check to see if the controller and RTU are still able to communicate with each other. The system is also configured for exception reporting by the RTUs to update the controller.

When the system is first powered up, the controller does not have any valid RTU status. All RTU queries will result in radio transmissions until the controller has obtained and stored the initial RTU status. After this, exception reporting of the RTUs keeps the controller up to date.

The Model 1730 controller must transmit all commands to change output status or clear accumulators, counters, or run-times out to the RTU. These commands always result in a radio transmission to the RTU.

MODBUS Report By Exception

National Instruments has a feature in their Lookout software called "poll upon receipt of unsolicited message", which causes Lookout to do a poll if a device sends a message without first being queried. To accommodate this feature, the Model 1732 RTU (with v2.00 or later software) can send exception reports using the MODBUS protocol over either direct serial or dial-up telephone connections.

MODBUS Query Errors

The Model 1730/Model 1732 MODBUS implementation is limited to 400 inputs or coils, or 80 holding or input registers per query. The Model 1730/1732 returns a MODBUS data address exception if a query exceeds these limits. Data address exceptions are also returned if

an attempt is made to access a point on an I/O module that is not installed and configured or an I/O address outside the allowed range. A MODBUS data value exception is returned if the value sent to an analog output holding register is out of the allowed range.

For details on MODBUS data address and value exceptions, see your SCADA program documentation.

INPUTS AND OUTPUTS

In MODBUS protocol, each I/O point is given a unique address. The address tells the PC SCADA program how to access the I/O point. Some MODBUS programs require leading 0s in coil addresses and some do not. Please check your MODBUS program documentation. The following subsections list the addresses or address ranges to use in a MODBUS system.

Model 1730/1732

Core Module I/O

Core digital inputs values are 0 for inactive (open contact, high voltage, or no connection) and 1 for active (contact closure to ground or low voltage).

Core output (coil) values are 0 for inactive (off) and 1 for active (on). Outputs 1 through 4 are open-collector relay drivers that present an open circuit when turned off and ground when turned on. Output 5 is a form C relay.

Table 3. Core Input and Coil Address Ranges

Input Status Address Range	10001 - 10008
Coil Address Range	00001 - 00005

Digital I/O Modules

When configured as an input, the I/O value is 0 for inactive (open contact, high voltage, or no connection) and 1 for active (contact closure to ground or low voltage).

When configured as an output, the I/O value is 0 for inactive (off) and 1 for active (on). The outputs on the digital I/O module are open-collector relay drivers with a pull-up resistor to the power supply voltage. They provide the power supply voltage when turned off, and they provide ground when turned on.

See Table 4 for a list of Digital I/O address ranges.

Table 4. Digital I/O Input and Coil Address Ranges

Module Address	Input Status Address Range	Coil Address Range
0	11001 - 11016	01001 - 01016
1	11017 - 11032	01017 - 01032
2	11033 - 11048	01033 - 01048
3	11049 - 11064	01049 - 01064
4	11065 - 11080	01065 - 01080
5	11081 - 11096	01081 - 01096
6	11097 - 11112	01097 - 01112
7	11113 - 11128	01113 - 01128
8	11129 - 11144	01129 - 01144
9	11145 - 11160	01145 - 01160
10	11161 - 11176	01161 - 01176
11	11177 - 11192	01177 - 01192
12	11193 - 11208	01193 - 01208
13	11209 - 11224	01209 - 01224
14	11225 - 11240	01225 - 01240
15	11241 - 11256	01241 – 01256

Relay Output Modules

The relay output values are 0 (off) for inactive, and 1 (on) for active.

Table 5. Relay Output Coil Address Ranges

Module Address	Coil Address Range	Module Address	Coil Address Range
0	02001 - 02006	9	02055 - 02060
1	02007 - 02012	10	02061 - 02066
2	02013 - 02018	11	02067 - 02072
3	02019 - 02024	12	02073 - 02078
4	02025 - 02030	13	02079 - 02084
5	02031 - 02036	14	02085 - 02090
6	02037 - 02042	15	02091 - 02096
7	02043 - 02048		
8	02049 - 02054		

Analog Input Modules

The raw analog input values range from 0 to 4096, which represents measured values of –10 V to +10 V or –40 mA to +40 mA approximately[i].

Table 6. Analog Input Address Ranges

Module Address	Input Register Address Range
0	31001 - 31011
1	31012 - 31022
2	31023 - 31033
3	31034 - 31044
4	31045 - 31055
5	31056 - 31066
6	31067 - 31077
7	31078 - 31088
8	31089 - 31099
9	31100 - 31110
10	31111 - 31121
11	31122 - 31132
12	31133 - 31143
13	31144 - 31154
14	31155 - 31165
15	31166 - 31176

Some useful raw values and their corresponding voltage and current measurements are given in Table 7.

Table 7. Analog Input Equivalent Values

Raw Value	Voltage	Current
2048	0 V	0 mA
3072	5 V	20 mA
2252.8	1 V	4 mA

[i] The maximum raw value of an analog input is really 4095, which represents a measured value of +9.995 V or +39.98 mA. It is usually more convenient, when configuring the MODBUS application software, to use a maximum raw value of 4096 and measured value of +10 V or +40 mA.

Analog Output Modules

The raw analog output values range from 0 to 255, which represents measured values of 0 V to 4.9805 V or 0 mA to 19.922 mA[ii].

Table 8. Analog Output Address Ranges

Module Address	Holding Register Address Range
0	41001 - 41004
1	41005 - 41008
2	41009 - 41012
3	41013 - 41016
4	41017 - 41020
5	41021 - 41024
6	41025 - 41028
7	41029 - 41032
8	41033 - 41036
9	41037 - 41040
10	41041 - 41044
11	41045 - 41048
12	41049 - 41052
13	41053 - 41056
14	41057 - 41060
15	41061 - 41064

Accumulators, Counters and Run Times

The Model 1730 and Model 1732 offer two different ways to access accumulators, counters, and run time holding registers: binary format and modulo-10000 format.

Each accumulator, counter and run-time consists of two parts: 1) the measured value and 2) the period (in seconds) over which the measurement was taken. The value (except for the accumulator average) and period are both too large to fit in a single holding register, so they are accessed through multiple consecutive holding register addresses.

Because the accumulator measured value (average analog input reading) is small enough to fit in a single holding register, the binary and modulo-10000 formats are the same. The

[ii] For analog outputs, the MODBUS application software should be configured using raw units of 0 to 255 and measured units of 0 to 4.9805 V or 0 to 19.922 mA. Using a maximum raw value of 256 and maximum measured value of 5 V or 20 mA gives the same scaling, but will cause a data value exception if the application program tries to set the output to the maximum value.

measured value for counters and run-times and the period for accumulators, counters and run-times all span multiple holding registers.

In binary format, the value and period are both 32-bit unsigned numbers. Each takes up two consecutive 16-bit holding registers (the most significant word at the lower address).

In the modulo-10000 format, the value and period are each spread over three consecutive holding registers with four decimal digits in each. The register with the lowest address contains the least significant digits. For example, if the counter for the core digital input 5 has a value of 1234567890, register 43125 will contain 7890, register 43126 will contain 3456, and register 43127 will contain 12.

Any write (force single register or force multiple registers) to the first address of an accumulator, counter, or runtime clears both the measured value and the period.

When querying accumulators, counters, or run-times, both the value and period must be read at the same time. Reading the count and period separately is not allowed. This is usually accomplished by telling the SCADA program to group the holding register addresses together into a single unit.

Table 9. Accumulator Addresses

Model 1730/1732 Accumulator	Binary Holding Register Access		Mod-10000 Holding Register Access	
	Average Address	Period Address Range	Average Address	Period Address Range
1	42001	42002 - 42003	42101	42102 - 42104
2	42004	42005 - 42006	42105	42106 - 42108
3	42007	42008 - 42009	42109	42110 - 42112
4	42010	42011 - 42012	42113	42114 - 42116
5	42013	42014 - 42015	42117	42118 - 42120
6	42016	42017 - 42018	42121	42122 - 42124
7	42019	42020 - 42021	42125	42126 - 42128
8	42022	42023 - 42024	42129	42130 - 42132
9	42025	42026 - 42027	42133	42134 - 42136
10	42028	42029 - 42030	42137	42138 - 42140
11	42031	42032 - 42033	42141	42142 - 42144

Table 10. Counter Addresses

Model 1730/1732 Counter	Binary Holding Register Access		Mod-10000 Holding Register Access	
	Count Address Range	Period Address Range	Count Address Range	Period Address Range
1	43001 - 43002	43003 - 43004	43101 - 43103	43104 - 43106
2	43005 - 43006	43007 - 43008	43107 - 43109	43110 - 43112
3	43009 - 43010	43011 - 43012	43113 - 43115	43116 - 43118
4	43013 - 43014	43015 - 43016	43119 - 43121	43122 - 43124
5	43017 - 43018	43019 - 43020	43125 - 43127	43128 - 43130
6	43021 - 43022	43023 - 43024	43131 - 43133	43134 - 43136
7	43025 - 43026	43027 - 43028	43137 - 43139	43140 - 43142
8	43029 - 43030	43031 - 43032	43143 - 43145	43146 - 43148

Table 11. Run-time Addresses

Model 1730/1732 Run Time	Binary Holding Register Access		Mod-10000 Holding Register Access	
	Run Time Address Range	Period Address Range	Run Time Address Range	Period Address Range
1	44001 - 44002	44003 - 44004	44101 - 44103	44104 - 44106
2	44005 - 44006	44007 - 44008	44107 - 44109	44110 - 44112
3	44009 - 44010	44011 - 44012	44113 - 44115	44116 - 44118
4	44013 - 44014	44015 - 44016	44119 - 44121	44122 - 44124
5	44017 - 44018	44019 - 44020	44125 - 44127	44128 - 44130
6	44021 - 44022	44023 - 44024	44131 - 44133	44134 - 44136
7	44025 - 44026	44027 - 44028	44137 - 44139	44140 - 44142
8	44029 - 44030	44031 - 44032	44143 - 44145	44146 - 44148

Accumulator Calculations

The accumulator returns the average value of the corresponding analog input over the measurement period. This is a number between 0 and 4096, representing an average input value of -10 to +10 V or -40 to +40 mA.

The period is the number of seconds since the last time the accumulator was cleared. Since the analog input is read once per second, the period also represents the number of input samples taken.

The average can usually be scaled automatically by the SCADA application software to the engineering units used by the sensor (e.g., gallons per minute). Calculating the total accumulated value usually involves writing a script. The equation for this calculation is:

Total = average x period / seconds-per-sensor time units

In this equation, the average is the average analog input value in engineering units (such as gallons per minute). The seconds-per-sensor time units is a conversion factor that reconciles the time units of the period (seconds) and sensor (which could be any time unit).

Here is an example to clarify how the accumulator works. A sensor that measures gallons per minute is attached to an analog input. The accumulator for that input is cleared and read again three hours later. The accumulator average value at this time is 50.3 gallons per minute. The period is 10800 seconds (three hours). The sensor time units are minutes, so the divisor is 60. The accumulated total flow is:

Total = 50.3 gallons per minute x 10800 seconds / 60 seconds per minute
= 9054 gallons

RTUBASIC Register Variables

RTUBASIC register variables can be read from and written to through the MODBUS protocol using MODBUS holding registers. There are two ways to access RTUBASIC register variables - either in their natural (Integer or Real) format, or in Modulo-10000 format.

When accessing RTUBASIC register variables in their natural format, each register variable uses two consecutive holding register addresses. The format of the data in the holding registers depends on the type of the register variable declared in the RTUBASIC program. If the register variable is declared an Integer type, the holding registers contain a 32-bit signed integer value. If the register variable is declared a Real type, the holding registers contain a 4-byte floating point value.

When accessing RTUBASIC register variables in Modulo-10000 format, different address ranges are used depending on whether the register variable is an Integer or Real type. In either case, each RTUBASIC register variable takes up three consecutive MODBUS holding register addresses. The Modulo-10000 format does not allow for signed numbers or for decimal places. For Integer type register variables, values are clipped to the range 0 to 2147483647, and for Real type register variables, values are clipped to the range 0 to 999,999,999,999 and lose their decimal digits.

Table 12 shows the relation ship between register numbers and addresses in the three different formats.

Table 12. RTUBASIC Register Variables

RTUBASIC Register Number	Natural Format Address (32-bit signed integer or 4-byte floating point)	Modulo-10000 Address Integer Register Variable	Modulo-10000 Address Real Register Variable
0	48001 - 48002	48201 - 48203	48401 - 48403
1	48003 - 48004	48204 - 48206	48404 - 48406
2	48005 - 48006	48207 - 48209	48407 - 48409
3	48007 - 48008	48210 - 48212	48410 - 48412
4	48009 - 48010	48213 - 48215	48413 - 48415
5	48011 - 48012	48216 - 48218	48416 - 48418
6	48013 - 48014	48219 - 48221	48419 - 48421
7	48015 - 48016	48222 - 48224	48422 - 48424
8	48017 - 48018	48225 - 48227	48425 - 48427
9	48019 - 48020	48228 - 48230	48428 - 48430
10	48021 - 48022	48231 - 48233	48431 - 48433
11	48023 - 48024	48234 - 48236	48434 - 48436
12	48025 - 48026	48237 - 48239	48437 - 48439
13	48027 - 48028	48240 - 48242	48440 - 48442
14	48029 - 48030	48243 - 48245	48443 - 48445
15	48031 - 48032	48246 - 48248	48446 - 48448
16	48033 - 48034	48249 - 48251	48449 - 48451
17	48035 - 48036	48252 - 48254	48452 - 48454
18	48037 - 48038	48255 - 48257	48455 - 48457
19	48039 - 48040	48258 - 48260	48458 - 48460
20	48041 - 48042	48261 - 48263	48461 - 48463
21	48043 - 48044	48264 - 48266	48464 - 48466
22	48045 - 48046	48267 - 48269	48467 - 48469
23	48047 - 48048	48270 - 48272	48470 - 48472
24	48049 - 48050	48273 - 48275	48473 - 48475
25	48051 - 48052	48276 - 48278	48476 - 48478
26	48053 - 48054	48279 - 48281	48479 - 48481
27	48055 - 48056	48282 - 48284	48482 - 48484
28	48057 - 48058	48285 - 48287	48485 - 48487
29	48059 - 48060	48288 - 48290	48488 - 48490
30	48061 - 48062	48291 - 48293	48491 - 48493
31	48063 - 48064	48294 - 48296	48494 - 48496
32	48065 - 48066	48297 - 48299	48497 - 48499
33	48067 - 48068	48300 - 48302	48500 - 48502
34	48069 - 48070	48303 - 48305	48503 - 48505
35	48071 - 48072	48306 - 48308	48506 - 48508
36	48073 - 48074	48309 - 48311	48509 - 48511
37	48075 - 48076	48312 - 48314	48512 - 48514
38	48077 - 48078	48315 - 48317	48515 - 48517
39	48079 - 48080	48318 - 48320	48518 - 48520

RTUBASIC Register Number	Natural Format Address (32-bit signed integer or 4-byte floating point)	Modulo-10000 Address Integer Register Variable	Modulo-10000 Address Real Register Variable
40	48081 - 48082	48321 - 48323	48521 - 48523
41	48083 - 48084	48324 - 48326	48524 - 48526
42	48085 - 48086	48327 - 48329	48527 - 48529
43	48087 - 48088	48330 - 48332	48530 - 48532
44	48089 - 48090	48333 - 48335	48533 - 48535
45	48091 - 48092	48336 - 48338	48536 - 48538
46	48093 - 48094	48339 - 48341	48539 - 48541
47	48095 - 48096	48342 - 48344	48542 - 48544
48	48097 - 48098	48345 - 48347	48545 - 48547
49	48099 - 48100	48348 - 48350	48548 - 48550

Model 1708/1716 RTU

Digital and Analog I/O

The Model 1708 and Model 1716 have the numbers of I/O listed in Table 13.

Table 13. Model 1708/1716 Inputs and Outputs

Model	Digital Inputs	Digital Outputs	Analog Inputs	Analog Outputs
1708	8	8	4	0
1716	16	16	8	4

Digital inputs values are 0 for inactive (open contact, high voltage, or no connection) and 1 for active (contact closure to ground or low voltage).

Digital output values are 0 for inactive (off) and 1 for active (on). All outputs are open collector relay drivers that present an open circuit when turned off and ground when turned on.

Analog input raw values range from 0 to 255, which represents 0 V to 4.980 V or 0 mA to 19.92 mA.

Analog output raw values range from 0 to 255, which represents 0 V to 4.980 V or 0 mA to 19.92 mA.

Table 14. Model 1708/1716 Input, Coil, and Register Addresses

RTU Model	Input Status Address Range	Coil Address Range	Input Register Address Range	Holding Register Address Range
1708	10001 - 10008	00001 - 00008	30001 - 30004	N/A
1716	10001 - 10016	00001 - 00016	30001 - 30008	40001 - 40004

Accumulators

Each analog input on the Model 1708/1716 has an associated accumulator.

For details on accessing and using accumulators, see "Accumulators, Counters and Run Times" on page 20.

The main difference between Model 1708/1716 accumulators and Model 1730/1732 accumulators is that for the Model 1708/1716, the average value has raw units in the range 0 to 256, which represents an average analog input value of 0 V to 5 V or 0 mA to 20 mA. Whereas for the Model 1730/1732, the raw analog input values range from 0 to 4096, which represents measured values of –10 V to +10 V or –40 mA to +40 mA approximately. The calculation of the total accumulated value is the same as for the Model 1730/1732.

The Model 1708/1716 have a configurable sample rate for each analog input. This should be left at the default value of 10 (1 sample per second). Even if it is set to some other rate, the Model 1730 controller will normalize the accumulator as if it were running at a sample rate of once per second, so there is no reason to set the RTU sample rate to any other value.

Unlike Model 1730/1732 accumulators, Model 1708/1716 accumulators must be accessed one at a time. An address exception occurs if more than one accumulator is addressed in a query.

Table 15. Model 1708/1716 Accumulator Addresses

Model 1708/1716 Accumulator	Binary Holding Register Access		Mod-10000 Holding Register Access	
	Average Address	Period Address Range	Average Address	Period Address Range
1	42001	42002 - 42003	42101	42102 - 42104
2	42004	42005 - 42006	42105	42106 - 42108
3	42007	42008 - 42009	42109	42110 - 42112
4	42010	42011 - 42012	42113	42114 - 42116
5	42013	42014 - 42015	42117	42118 - 42120
6	42016	42017 - 42018	42121	42122 - 42124
7	42019	42020 - 42021	42125	42126 - 42128
8	42022	42023 - 42024	42129	42130 - 42132

The accumulators in the Model 1708/1716 units will run for at least 97 days before overflowing.

Counters

Each digital input on the Model 1708/1716 also has an associated counter.

Access of Model 1708/1716 counters is exactly the same as for the Model 1730/1732. For details on accessing counters, see "Accumulators, Counters and Run Times" on page 20.

Unlike Model 1730/1732 counters, Model 1708/1716 counters must be accessed one at a time. An address exception occurs if more than one counter is addressed in a query.

Table 16. Model 1708/1716 Counter Addresses

Model 1708/1716 Counter	Binary Holding Register Access		Mod-10000 Holding Register Access	
	Count Address Range	Period Address Range	Count Address Range	Period Address Range
1	43001 - 43002	43003 - 43004	43101 - 43103	43104 - 43106
2	43005 - 43006	43007 - 43008	43107 - 43109	43110 - 43112
3	43009 - 43010	43011 - 43012	43113 - 43115	43116 - 43118
4	43013 - 43014	43015 - 43016	43119 - 43121	43122 - 43124
5	43017 - 43018	43019 - 43020	43125 - 43127	43128 - 43130
6	43021 - 43022	43023 - 43024	43131 - 43133	43134 - 43136
7	43025 - 43026	43027 - 43028	43137 - 43139	43140 - 43142
8	43029 - 43030	43031 - 43032	43143 - 43145	43146 - 43148
9	43033 - 43034	43035 - 43036	43149 - 43151	43152 - 43154
10	43037 - 43038	43039 - 43040	43155 - 43157	43158 - 43160
11	43041 - 43042	43043 - 43044	43161 - 43163	43164 - 43166
12	43045 - 43046	43047 - 43048	43167 - 43169	43170 - 43172
13	43049 - 43050	43051 - 43052	43173 - 43175	43176 - 43178
14	43053 - 43054	43055 - 43056	43179 - 43181	43182 - 43184
15	43057 - 43058	43059 - 43060	43185 - 43187	43188 - 43190
16	43061 - 43062	43063 - 43064	43191 - 43193	43194 - 43196

The Model 1708/1716 counters will hold a maximum count of 16,777,215 pulses. If fed pulses at the fastest possible rate (10 per second), the counter will run for 19 days before overflowing.

Run-Time

The Model 1708/1716 RTUs do not support run-time measurements.

INSTALLATION

OVERVIEW

Each device (controller or RTU) consists of an enclosure and modules mounted within the enclosure. There are nine different modules categorized into four types:

Core module (which must be included in each device)

Input/output modules

- Digital input/output
- Relay output
- Analog input
- Analog output

Communication modules

- Radio interface
- Phone modem

Power modules

- AC power
- Battery charger

This section tells you how to install the Model 1730 controller and the Model 1730 RTU. Information on installing and running your SCADA program is not covered. Information about adding modules and upgrading device firmware is presented at the end of this section.

Before starting you should know which modules go into which devices, the power source and field wiring (sensors, pumps, etc.) for each device, and the communication channels your system will use. Make a list or diagram of your system, read through this section, and then organize the modules, enclosures, and equipment.

Note

The core modules for controllers and RTUs are not interchangeable. The core module firmware installed at the factory is specific to controllers or RTUs. A label near J2 on the core module indicates which firmware is loaded into the module.

The label used to indicate firmware is shown in Figure 4.

Figure 4. Example of Label That Indicates Firmware

REQUIRED TOOLS AND EQUIPMENT

- 9-inch long #2 Phillips screwdriver
- PC running the Configuration Utility (Part No. 950-0050), serial communication cable (Part No. 709-0001 or equivalent), and the *RTU Configuration Utility User's Manual*, Part No. 025-9445
- Terminal blocks and connectors for field wiring (these are supplied with the modules)

Note

All devices must be configured with the Zetron RTU Configuration Utility regardless of the type of system.

Configuration Utility

The Configuration Utility is a Windows 95-based program used to configure the devices for use with the user's specific application.

With this program, the user is able to perform three main functions on a device:

1. Read/write, modify, and save a device's operating parameter configuration
2. Upgrade a device's firmware (see "UPGRADING DEVICE FIRMWARE" on page 45)
3. Retrieve/clear Logger data (RTU only). See "RTU SPECIAL FUNCTIONS" starting on page 11.

The first function is the primary purpose of the Configuration Utility. Using the program, the user can read a device's current settings, modify the settings, save them to a configuration file, and write the new settings back to the device. The program also generates local logic programs for RTUs using "wizards" (e.g., for pump rotation, communications failure, data logging start-stop).

For further information, see the *RTU Configuration Utility User's Manual*, Part No. 025-9445.

INSTALLATION STEPS

Installation of the controller and RTUs consists of eight steps:

1. Using the Configuration Utility to organize device and module information, especially names and addresses
2. Mounting the enclosures and modules
3. Connecting the expansion cable to the modules
4. Setting switches on the modules
5. Connecting power to the device
6. Connecting the communication channels to the device
7. Connecting the field wiring to the modules
8. Configuring the device using the Configuration Utility

After installation, run your SCADA program to check the system, read inputs, and set outputs.

You may vary the sequence depending on the location of the remote sites, installation work spaces, and I/O field wiring. In all cases, please read through this section before starting.

USING THE CONFIGURATION UTILITY

To simplify the rest of the installation, install and run the Configuration Utility to become familiar with it and the settings you will make later on. You can create preliminary configuration files for your devices and their modules. Most modules in your system must have a module address. In the preliminary configuration files, you can assign addresses and then print out reports so your settings are documented. The print outs can also be used to check the switches in the devices.

However, the last step of installing a device is to configure it using the Configuration Utility. At that time, it is best to start a new configuration file by reading (downloading) from the device. Your preliminary file is replaced by the configuration file read in from the device. Reading the configuration from the device ensures that the correct addresses and number and type of modules are in the file.

For more information about the Configuration Utility, see the *RTU Configuration Utility User's Manual*, Part No. 025-9445.

MOUNTING ENCLOSURES AND MODULES

Three types of enclosures are used for the Model 1730 and Model 1732: a Zetron box, a medium NEMA enclosure, and a large NEMA enclosure. The Zetron box is intended for protected areas and smaller systems. The two NEMA enclosures provide NEMA type 4 protection from water and provide mounting for both the I/O modules and customer-supplied equipment. For the mounting dimensions of the three types of enclosure, see Appendix A.

Depending on your application, a variety of modules are mounted inside the enclosures. However, each device must have either a controller core module or an RTU core module.

Zetron Box

The Zetron box provides six module spaces. To accommodate more modules, an additional Zetron Box can be mounted against the first box; this provides a somewhat protected path for the expansion cable (see “EXPANDING AN EXISTING DEVICE” on page 44).

Figure 5 shows the location of the core module and the direction to add modules. It also shows an additional Zetron box and expansion cable.

To close the metal lid, first hook the pin in the lid into the hole in the rear of the base plate. Then rotate the lid down until the catch latches on the front bottom of the box.

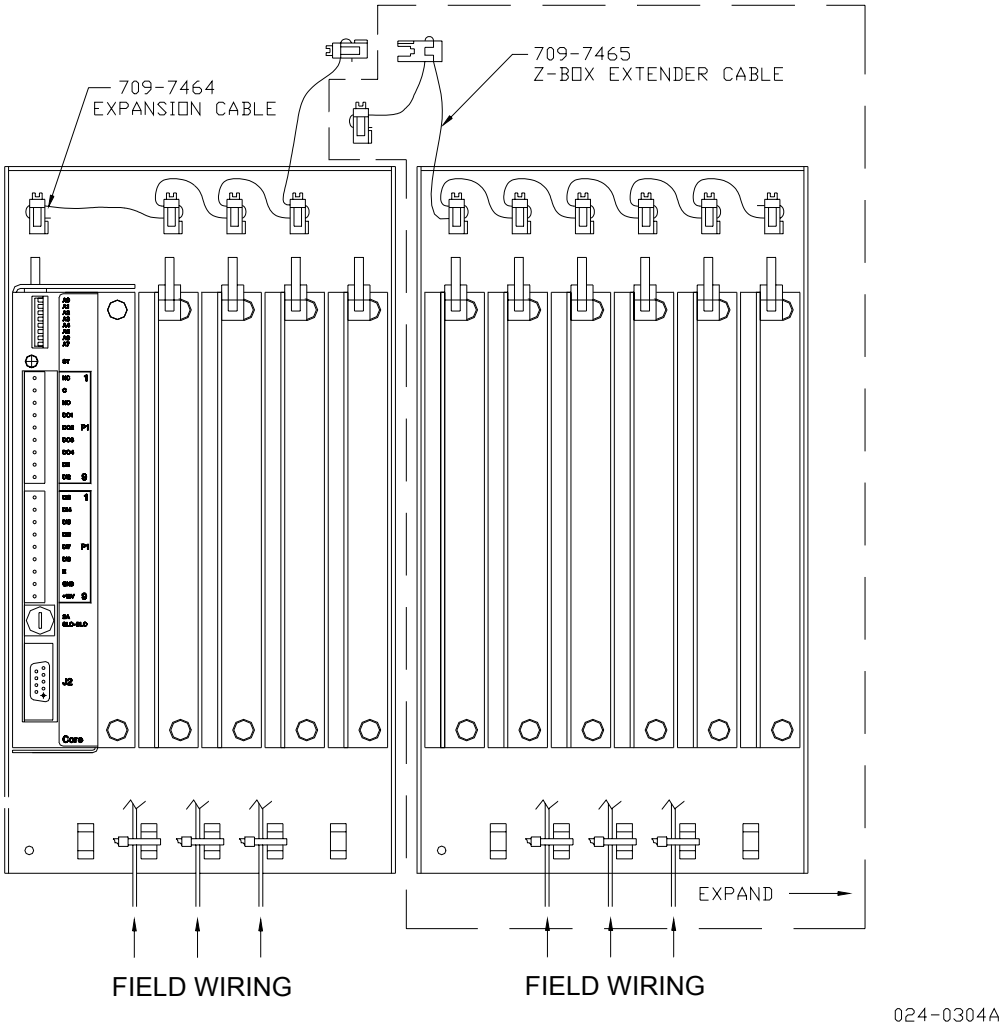


Figure 5. Zetron Box Module Installation

NEMA Enclosures

A medium NEMA enclosure is 16 x 14 x 6 inches and has 15 module spaces. A large NEMA enclosure is 24 x 20 x 8 inches and has 30 module spaces. The box material can be steel or fiberglass. For mounting customer-supplied equipment in a NEMA enclosure, Zetron provides blank mounting plates (Part No. 950-0045). Mount the customer-supplied equipment onto a blank plate and then fasten the plate to the backplane in the NEMA enclosure.

Figure 6 shows the location of the core module and the direction for expansion when adding modules to a medium NEMA enclosure. The figure also shows the expansion cable.

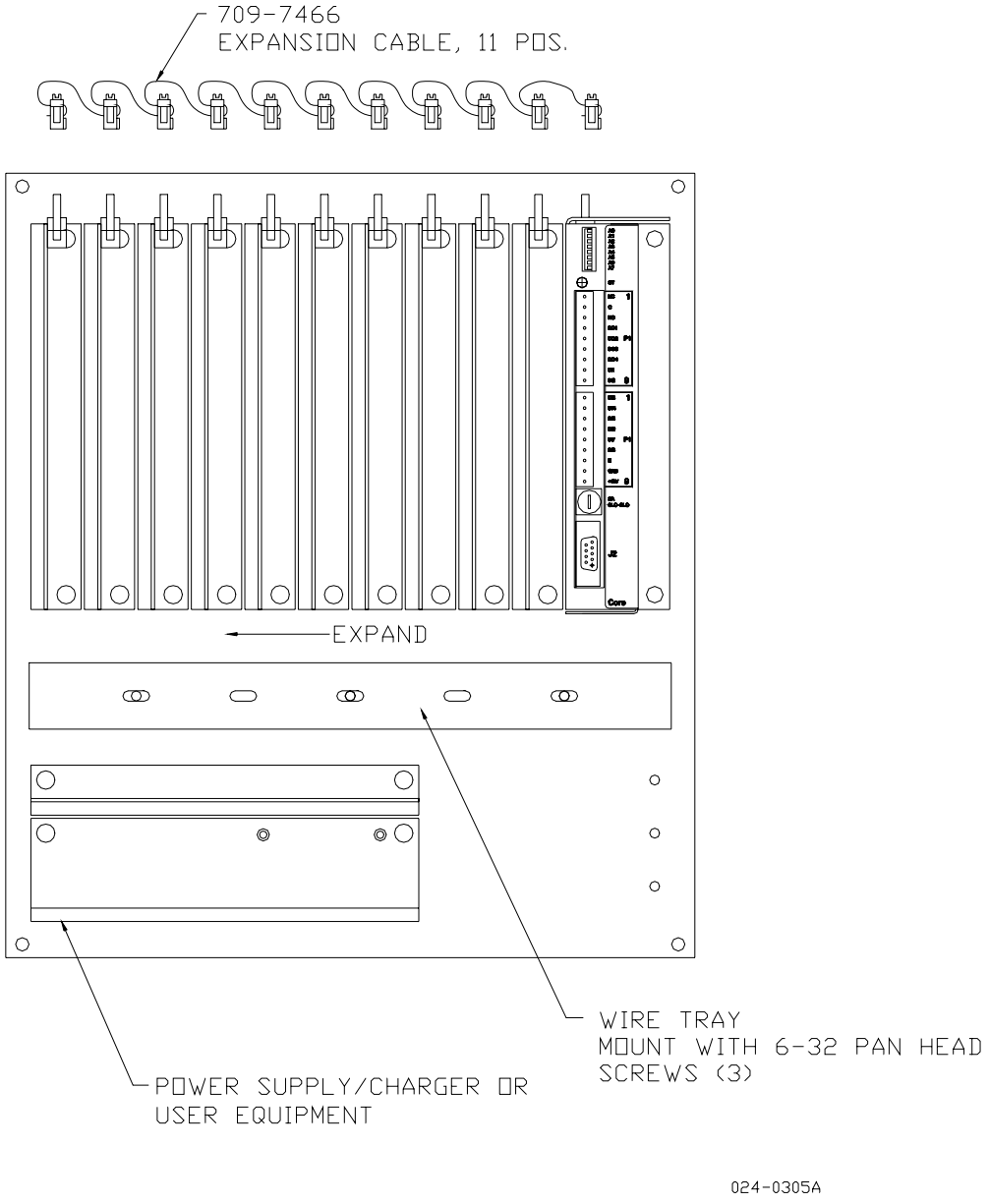


Figure 6. Medium NEMA Enclosure Module Installation

Figure 7 shows the location of the core module and the direction for expansion when adding modules to a large NEMA enclosure. It also shows the proper expansion cable to be used to expand a system.

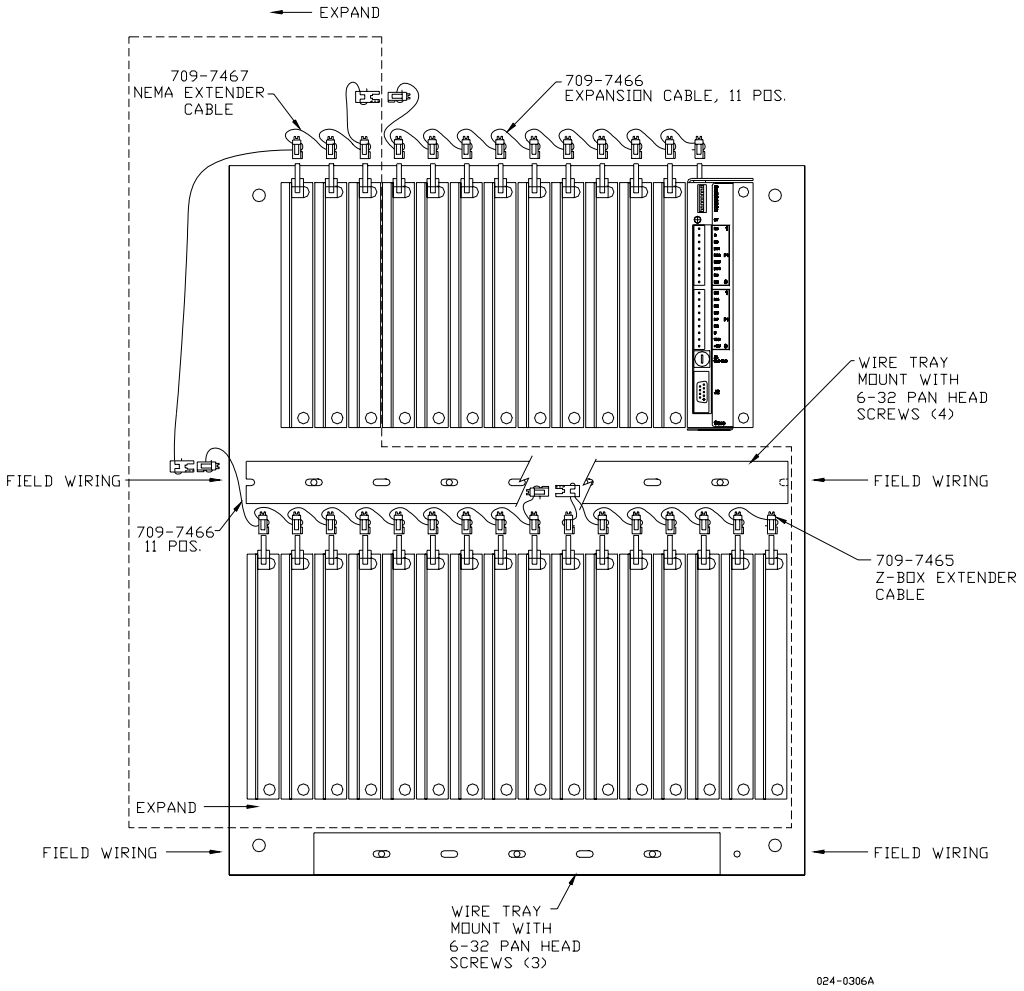


Figure 7. Large NEMA Enclosure Module Mounting

If you are using a customer-supplied enclosure, Zetron provides NEMA mounting plates. Appendix A shows the dimensions for the mounting plates. The depth of the customer-supplied enclosure should be 6 inches minimum.

Mounting the Modules

In each box or enclosure, plan to mount your modules in the expansion direction shown in Figure 5 (for a Zetron box), Figure 6 (for a medium NEMA enclosure), and Figure 7 (for a large NEMA enclosure).

Mount all I/O modules of a single type (e.g., all DIO) together to make it easier to verify that the address DIP switches are correctly set later on.

If a device has a battery charger module, mount it next to the AC power module.

All modules mount in the same way. The mounting holes on the backplane of the enclosure are 1 inch apart, and the modules are either 1 or 2 inches wide. Each module has retained mounting screws. Use a 9-inch long #2 Phillips screwdriver to fasten each module to the backplane. Be careful to properly align the screw with the mounting hole so not to strip the screw or hole while tightening. See Figure 8.

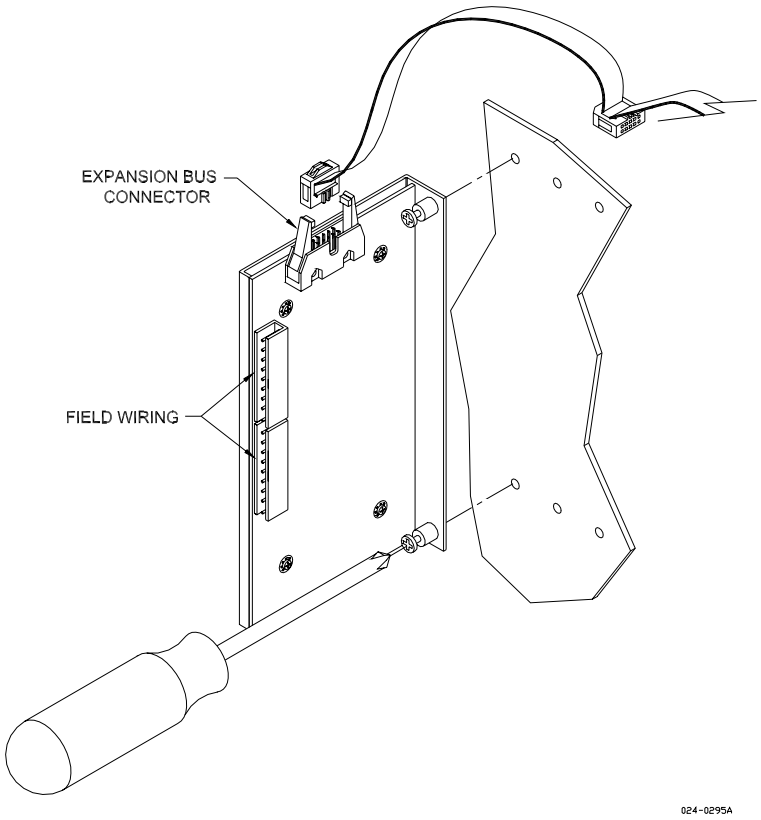


Figure 8. Mounting a Module on the Enclosure Backplane

CONNECTING THE EXPANSION CABLE

The I/O and communication modules receive their power and communicate through the expansion cable that connects to the expansion bus connector at the top of each module. The connectors are keyed so they can only be connected in one direction.

Figure 9 shows the expansion cables (used to connect the core modules to the communication and I/O modules) and the extender cables (used to connect additional modules beyond the basic set).

Because customer-supplied equipment is often installed in the NEMA enclosures, the NEMA enclosure expansion cables do not allow the box to be filled with modules. To fill a NEMA enclosure with the maximum number of modules, use an extender cable.

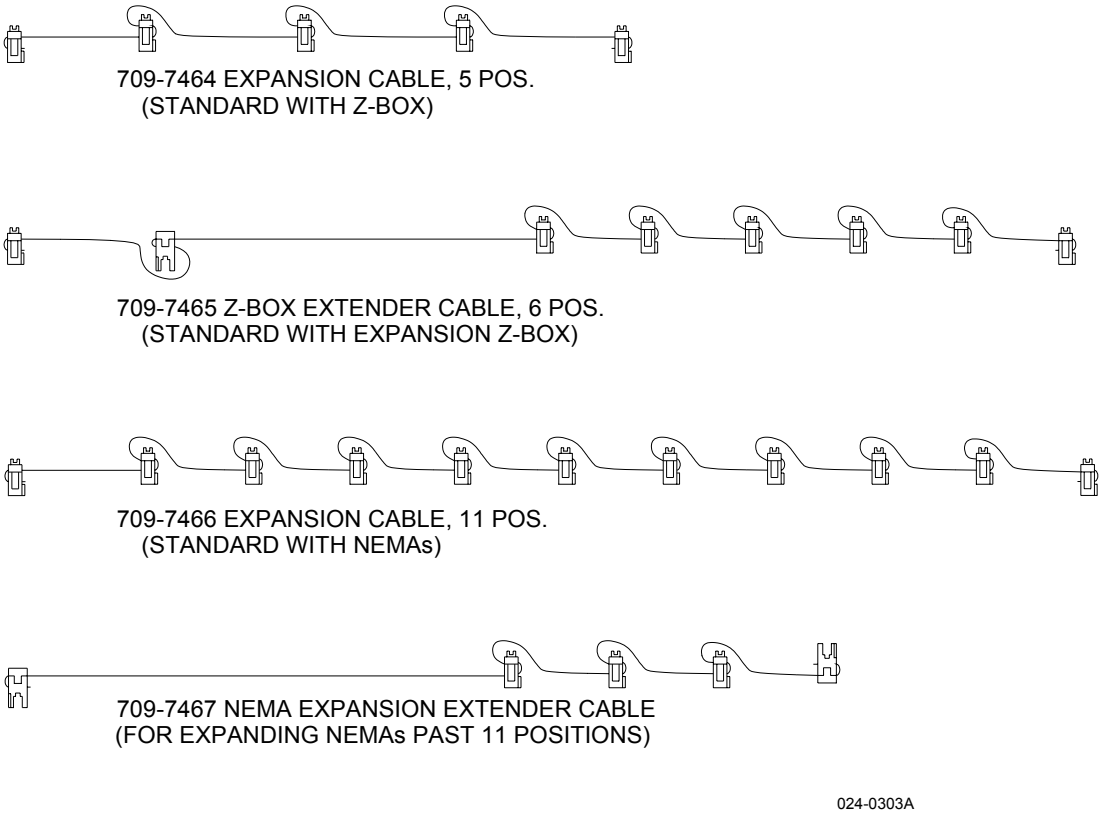

709-7464 EXPANSION CABLE, 5 POS.
(STANDARD WITH Z-BOX)
709-7465 Z-BOX EXTENDER CABLE, 6 POS.
(STANDARD WITH EXPANSION Z-BOX)
709-7466 EXPANSION CABLE, 11 POS.
(STANDARD WITH NEMAs)
709-7467 NEMA EXPANSION EXTENDER CABLE
(FOR EXPANDING NEMAs PAST 11 POSITIONS)
024-0303A

Figure 9. Expansion and Extender Cables for Connecting Modules

Connect the cables in a Zetron box as shown in Figure 5. Connect the cables in a medium NEMA enclosure as shown in Figure 6. Connect the cables in a large NEMA enclosure as shown in Figure 7.

SETTING SWITCHES

Set the DIP switches for the module addresses and other module-specific settings.

In general, when a DIP switch is pushed towards the PCB, it represents binary 0 for addresses or it means the labeled function is active. When a DIP switch is pushed away from the PCB, it represents binary 1 for addresses or it means the labeled function is not active.

Module Address

Each core, I/O, and radio interface module has a DIP switch for its module address. The radio interface module must have an address of 0.

The DIP switch is the binary number representing the address. A switch pushed away from the PCB represents a 1; a switch pushed toward the PCB represents a 0. Table 17 shows the DIP switch settings for I/O module addresses (0 – 15). If all four switches are pushed toward

the PCB, the address is 0. And if all four switches are pushed away from the PCB, the address is 15.

Table 17. DIP Switch Settings for I/O Module Addresses

	Address															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Switch A0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Switch A1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
Switch A2	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
Switch A3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

You can also just set the switches as shown in the diagrams in the Configuration Utility (see "USING THE CONFIGURATION UTILITY" on page 31). Figure 10 shows two sample DIP switch diagrams from the Configuration Utility. The switch numbers in the diagram correspond to the black numbers on the switch housing and to A0, A1, A2, and A3 on the module label.

Figure 10. Sample DIP Switch Diagrams from the Configuration Utility

Core Module

The core module has an eight-position DIP switch. The core module address range is 0 to 65,535 (the DIP switch represents only the lower byte of the address). The core module address is also called the device address. This address is used for communications. It is composed of the DIP switch setting and the software address extension in the device firmware (set with the Configuration Utility).

The valid address range when using the MODBUS protocol is 1 to 246. Zetron has reserved the address 247 for future use.

I/O Modules

I/O modules have a four-position DIP switch. The I/O module address range is 0 to 15. Each module of a single type must have a unique address (e.g., within a device, you cannot have two DIO modules with the same address, but you can have an analog input module and a DIO module with the same address). To make it easier to verify that the proper DIP switches are set, group the modules by type and start at 0000 and go up by ones (see Table 17).

At power up, the device detects if two or more modules of the same type are set to the same DIP switch address. The modules' Status LEDs indicate the error by flashing, and none of the same-type-and-address modules will be used.

Module Specific Settings

Some modules have additional settings on DIP switches or push pins on the PCB that must be set. When a DIP switch is pushed towards the PCB, it means the labeled function is active. When a DIP switch is pushed away from the PCB, it means the labeled function is not active.

See the "MODULES" section, starting on page 55, for information about module-specific settings.

CONNECTING POWER

Requirements

Power required is 12–16 V_{dc}. The current requirements depend on the user's specific application, the configuration of modules, and the customer-supplied equipment in the system.

Modules that accept primary DC power have fuses. The Core and the attached modules are powered through the core module terminal blocks. Analog Output modules can generate a loop voltage source for 4-20 mA current outputs that require a separate primary power input. The radio module can either provide a primary power input for the radio with a maximum current of 2 A or interface with a separately powered radio. When using a battery-backed system, the large current draw for the radio can be provided by the battery, thus allowing the AC power supply to be smaller.

A power requirement analysis must be made for the system to ensure that power is supplied for the worst case scenario. The requirements of the customer-supplied equipment, such as radios, must also be accounted for.

The maximum current for each module is shown in Table 18. Use the table to determine maximum current required for your system.

Table 18. Power Requirements

Type	Qty	Max I	Subtotal (Qty*Max I)	Comment
Core Module	1	250		
Digital Input/Output		50		
Analog Input		50		
Analog Output		50		
Relay Output		200		
Radio Interface		100		
Phone Modem		100		
Radio				In battery-backed systems, you can get radio current from the battery.
4-20 mA Volt Source		200		
Customer Equipment				
		Total		

Power Sources

AC Power Module

The AC power module provides enough power for most systems. It provides 2 A at 16 V_{dc} that can power the device directly or it can power the battery charger module. See the "MODULES" section, starting on page 55, for detailed information on this module.

CAUTION

Fasten the AC power module to the backplane *before* connecting the AC power and protective ground.

The AC power connection must include three connections: line, neutral, and protective ground. The AC power wires must be strapped to the module using the tie wraps provided in the bagged kit for the AC power module.

The AC power module has a fuse and a single pole switch for disconnecting the AC power from the device. To protect against excess current, short circuits, and earth faults in the circuits before the fuse and switch, you must insert a disconnect in the wiring to the AC power module. A single pole disconnect may be used unless neutral in the primary supply cannot be reliably identified.

When an AC power module is replaced, first disconnect the AC power from the device.

Battery Charger Module

The battery charger module charges a backup battery and protects it from over-discharge. The module requires a power source of 16 V_{dc}, which is provided by the AC power module or a customer-supplied voltage source of 16.0 ±0.25 V_{dc} with a 2 A current capacity. The battery can be a Zetron-supplied 7-AH (Part No. 950-9733) or 12-AH (Part No. 950-9746) battery or a customer-supplied lead acid battery with a capacity of up to 15 AH.

The battery charger module also provides a digital output (PL on the module label) to indicate if primary AC power has failed.

For a device in a NEMA enclosure, place the battery in the bottom of the enclosure. For a device in a Zetron box, place the battery close to the box. The battery may be placed in any orientation except upside-down.

Using the wires included with the module, connect the battery charger module to the power source, to the power user (the core module), and to the battery (as shown in Figure 11). The yellow wire from PL on the battery charger module to DI8 on the core module is used to indicate power loss. Additional power users can be connected directly to the battery charger module's V+OUT and GND terminal blocks.

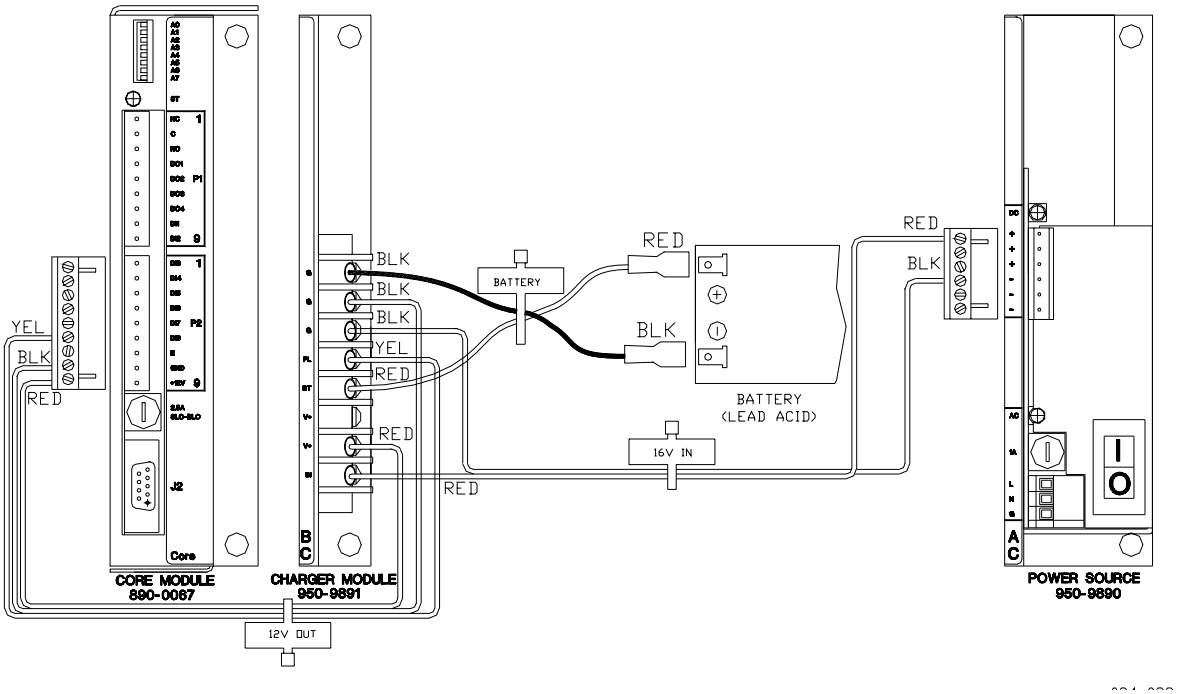


Figure 11. Battery Charger Module Connections

See the "MODULES" section for detailed information about the battery charger module.

External Vdc

If an external power source is used, it should be 12 or 16 V_{dc}: 12 V_{dc} to power a system directly or 16 V_{dc} to power the battery charger module. The power source does not have to be regulated because the modules regulate their own power. But it should be relatively stable (±10%) and not contain high frequency noise.

Taking Power from the Radio

An RTU can be powered from a radio. The power can be brought to the RTU using the radio connector. The power passes through the fuse on the radio interface module to the three-pin terminal block where it is wired to the core module. This set up has two fuses in the power for the RTU (one on the radio interface module and one on the core module).

Monitoring Power Voltage

To monitor the power voltage, use the built-in voltage divider on an analog input module and connect it to an extra analog input. This will allow monitoring of the power input voltage. For a battery-based system, this gives the capacity of the battery. For an AC powered system, it may provide an early warning of power problems.

System Grounding

To prevent noise from entering the measurements through the grounding system, the chassis ground should be connected to the power ground at a single point. To provide flexibility in system grounding, this connection must be made with field wiring. Depending on how the devices are used and the system grounding scheme, the single grounding point may or may not be in the RTU housing. The chassis ground is brought out to a terminal block on the core module to allow this flexibility.

CAUTION

The chassis ground must be connected to power ground using the field wiring.

Note that the AC power module connects the chassis to the AC protective earth ground.

Customer-Supplied Equipment

Customer-supplied equipment can be mounted inside the RTU or controller enclosure and share the power source. Use Table 18 to verify that the power source can supply the needed current.

CONNECTING THE COMMUNICATIONS CHANNEL

Because the main purpose of an RTU and controller is to communicate data one to another, setting up the communication channels is very important. The core module provides two RS-232 channels. Radio communication is provided by the radio interface module, and phone communication is provided by the phone modem module.

> **Note**
>
> The Model 1730 controller and Model 1732 RTU are shipped from the factory with only RS-232 communications enabled. To enable radio or phone communications, you must use the Configuration Utility to add the radio interface module or phone modem module to the device's configuration.

RS-232 Interface

The core module has two RS-232 channels: one is set up like a modem connector (J2), and the other is like a PC connector (P3). The baud rates, parity, and other settings are configured using the Configuration Utility.

In the Model 1730 controller, the core module J2 is used to communicate with the SCADA program. In the Model 1732 RTU, P3 can be used to communicate with a phone modem.

Radio Interface

The radio interface module provides a flexible interface to almost all types of radios. See the "MODULES" section, starting on page 55, for information on the radio interface module and its connections.

Phone Modem

The phone modem module provides a 2400 baud phone modem. If higher speeds are needed, the phone modem module may be replaced with any Hayes-compatible, AT command set external modem. See the "MODULES" section for further information on the phone modem module.

FIELD WIRING

For the wiring connections between the field instrumentation and equipment and the device modules, see the "MODULES" section.

System and Noise Considerations

Noise can be introduced into the measurement system either directly onto the signal being measured or indirectly by ground noise or common mode noise.

Figure 12 shows the equivalent circuits for the inputs and the filtering provided by each module.

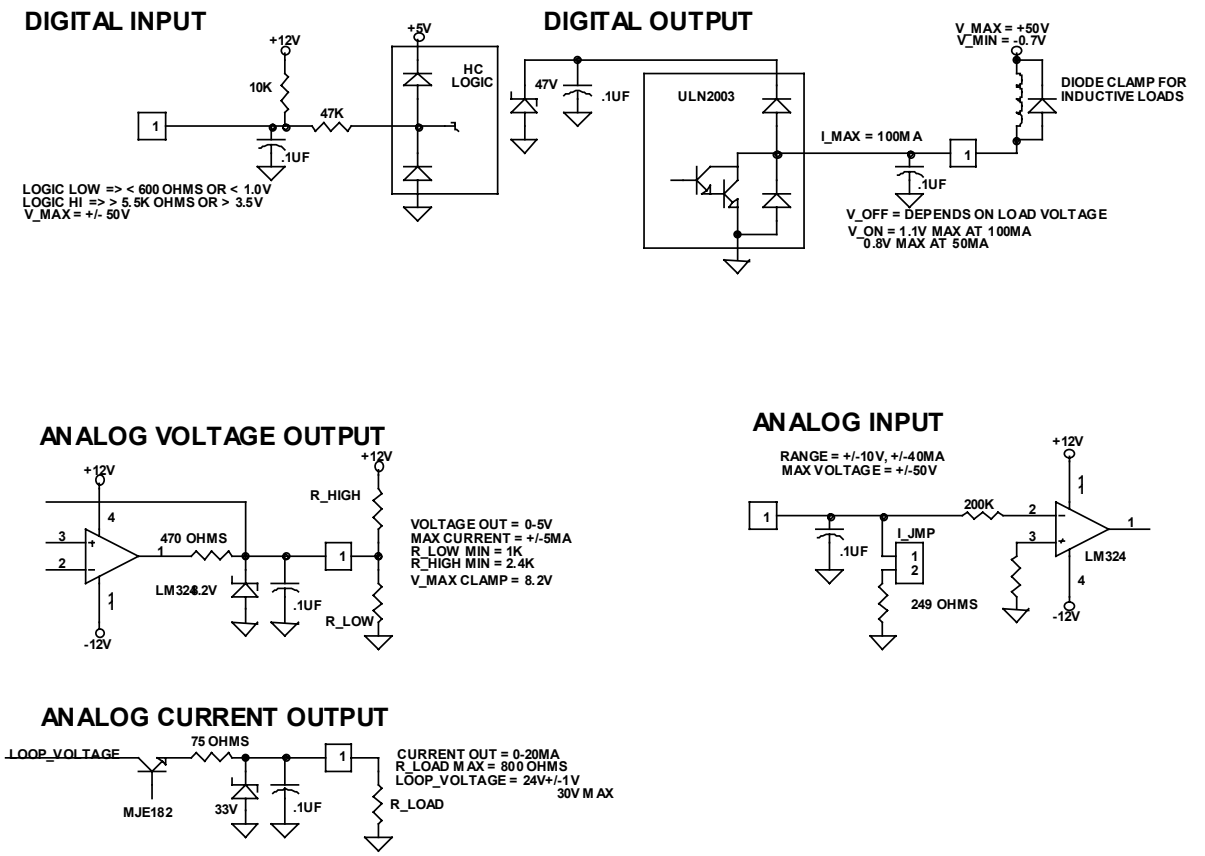


Figure 12. Equivalent Circuits for I/O Modules

Digital inputs can use the configurable debounce time settings to reject noise on inputs. This requires the input to be in a state continuously for the debounce time period before it will be recognized. The debounce time can be used to reject noise or to smooth out a bouncy sensor.

The digital output is actually a Darlington transistor (see Figure 12). The Digital I/O module provides a weak pull up to the power voltage (+12 V) while the core module does not provide a pull up. Each transistor is protected against overvoltage by a clamp diode at 47 V. The maximum current is 100 mA.

Analog inputs have an analog low pass filter before the A/D converter and a digital averaging filter after the A/D converter. This results in an effective low pass filter with roll off at 0.8 second to reject most noise sources. Analog signals can further be shielded from noise by using twisted pair and shielded wiring. Because the A/D inputs are single ended, referenced to the system ground, they can be sensitive to ground noise or common mode noise on the power ground. This can best be dealt with by analyzing the grounding system and placing the RTU system ground close (electrically) to the sensor being measured.

Recommendations

When the digital outputs are used to drive an inductive load (coil or solenoid), some protection is needed from the inductive kick that is generated when the drive is removed from the load. Each module provides some protection. Place a clamp diode across an inductive component for further protection.

Use extra analog inputs. Unused analog inputs can be used to make measurements that will aid in maintaining and calibrating the system.

System noise sources can be measured by wiring an extra analog input channel to a "dummy" sensor. The dummy sensor should be as similar to a real sensor as possible but not really perform the sensing. For example, to measure the noise sources for a variable resistor divider type sensor, a fixed resistor could be wired at the same location as the real sensor with a fixed divider. Thus by measuring the changes in the "dummy" sensor, the noise sources for the real sensor will be quantified.

CONFIGURING THE DEVICE USING THE CONFIGURATION UTILITY

Each device must be configured using the Configuration Utility (see "Configuration Utility" on page 30). Configuring a device includes: module addresses and inputs/outputs, communications settings, and special settings for reporting modes, data logging, and local logic.

The Model 1730 controller is configured *only* via its RS-232 connection (J2). The Model 1732 RTU can be configured via its RS-232 connection (J2), phone modem, or radio interface.

To install and run the Configuration Utility, see the *RTU Configuration Utility User's Manual*, Part No. 025-9445.

Configuring a device completes the installation. To test out the system, run your SCADA program. If you experience problems, see the "MAINTENANCE AND TROUBLESHOOTING" section starting on page 47.

EXPANDING AN EXISTING DEVICE

To expand an existing device, follow the steps for installing a new device (see "INSTALLATION STEPS" on page 31) and the information below.

Mounting Modules and Connecting Cables

Zetron Box

A Zetron box can be expanded by adding another box and extending the expansion cable (option Part No. 950-9993). By placing the boxes right next to each other, the expansion cable is protected between the two boxes. See Figure 5. There is no limit to this expansion other than the maximum number of 32 modules.

NEMA Enclosure

Figure 6 and Figure 7 show the expansion direction and expansion cabling for NEMA enclosures.

Configuring the Device

The configuration file has to be updated to account for the added modules. Use the Configuration Utility to call up the previous configuration stored on disk or retrieve the configuration previously loaded into a controller or an RTU. Update the device configuration file to recognize the new modules and download the new file to the device. See "Configuration Utility" on page 30 for more information.

Connecting Power, Communication Channels, and Field Wiring

Power is supplied to additional modules through the expansion cable. See the "MODULES" section for information on connecting the field wiring for each module.

Note

After adding a new module to a device, you must cycle power so the core module can detect the change.

UPGRADING DEVICE FIRMWARE

A device's firmware is field upgradable. Use the Configuration Utility running on a PC directly connected to the RS-232 (J2) connection on the device's core module. (Upgrading a device's firmware via the phone modem or radio interface is not supported.)

The Configuration Utility takes the new firmware file supplied by Zetron and writes it to the device in a simple one-step process.

The Configuration Utility only upgrades the firmware of a similar device. In other words, you cannot upgrade an RTU with Controller firmware and vice versa.

For further information, see the *RTU Configuration Utility User's Manual*, Part No. 025-9445.

MAINTENANCE AND TROUBLESHOOTING

SYSTEM CHECK USING LEDs

The LEDs on the modules indicate the operating condition of the module. The LEDs can be used as a simple check on the system operation.

Core Module Status LED

This subsection describes the LED flash patterns for the core module. A summary is shown in Table 19.

Table 19. Summary of Core Module Flash Patterns

Pattern	Explanation
Off	Startup
3.75 seconds off, 0.25 second on	Normal operation
0.75 second off, 0.25 second on	Low power
1 second off, flash twice	Errors

Startup

When the core module is initializing after power up, its LED is off. This may take up to 20 seconds.

Normal Operation

During normal operation, the core module LED flashes every 4 seconds (3.75 seconds off and 0.25 second on).

Low Power

When the core module, using its on-board comparators, detects a low power condition (see “Power Monitoring” on page 55), its LED flashes once per second (0.75 second off and 0.25 second on).

Error

When the core module detects an error, its LED flashes twice (1 second off, flash twice). This error indication usually means that a device has been configured to use a radio interface module or a phone modem module, but the module has not been installed.

I/O and Radio Interface Module Status LEDs

This subsection relates to all I/O modules and the radio interface module.

Each module has a status LED under the control of the local microprocessor. In general, when the module is working, the LED is mostly on; but if something is wrong, the LED is mostly off. The speed of the flashing indicates some detail regarding its status.

A summary of I/O and radio interface module flash patterns is shown in Table 20.

Table 20. Summary of I/O and Radio Interface Module Flash Patterns

Pattern	Explanation
On	Normal operation
Fast blink (0.2 second off, 0.8 second on)	No communication with core module
Off	Module errors
On and off (0.5 second off, 0.5 second on)	"I am here!" answer to core module command
Rapid flash (0.4 second off, 0.1 second on)	"Module error!" answer to core module command

Normal Operation

When a module is correctly configured, is successfully communicating with the core module, and does not detect any internal module errors, it turns its status LED on. Thus for normal operation, the LED is on.

No Communication with Core Module

A module that is not in communication with the core module indicates its condition with a fast blink (0.2 seconds off and 0.8 seconds on). And the module sets all its outputs to a safe condition. This pattern may also be seen at power up when the core module takes up to 20 seconds to initialize. This pattern is most often seen when a module is not configured even though it is connected to a core module.

Module Errors

If the module detects errors within the module itself, it turns the LED off if possible and attempts to set its outputs to a safe condition.

"I am here!" Answer to Core Module Command

When the core module commands it, the module indicates a "I am here!" with an equal sequence of on and off (0.5 second off and 0.5 second on). The "It's me!" flash pattern is used with the core module to indicate a module's identity to the user. This function is used for diagnostic functions.

"Module Error!" Answer to Core Module Command

When the core module commands it, the module indicates a module error with a rapid flash of the LED. A rapid flash is 0.4 second off and 0.1 second on. This function is used for diagnostic functions.

Phone Modem Module LEDs

The phone modem module's green LED simply indicates that its power is on. Its red LED indicates that the modem is offhook.

AC Power LEDs

The green DC output LED indicates that +16 V_{dc} power is available on the connector, and the red AC input LED indicates that the module is receiving power.

MODULE SELF-TESTS

The I/O and radio interface modules include a simple self-test to aid in troubleshooting suspected bad modules. The self-test is intended to be used by an electronics technician using common bench test equipment.

WARNING!

Do not perform a self-test on a device connected to field wiring because the outputs may change unpredictably!

The self-test is started the same way for each module:

1. Use a clip lead to ground the attention line, pin 7, on the expansion bus.
2. Power up the module.

The modules have components marked with GND and SELF-TEST to make this easier. The self-test continues to operate until the GND is removed from the SELF-TEST line or until a command is seen on the expansion bus.

See the "MODULES" section, starting on page 55, for a description of the self-test for I/O and radio interface modules.

LITHIUM BACKUP BATTERY

The core module in every device contains a lithium battery to back up system parameters and logged data. This battery is used only when the system power is off, and it will back up the data for 6–24 months.

To ensure continued backup, replace the lithium batteries periodically or as needed. Replace the lithium battery only with Zetron Part No. 416-0002 or industry type BR2325.

WARNING: DANGER OF EXPLOSION!

- Do not connect the positive (+) and negative (–) contacts of lithium batteries together.
- Do not dispose of lithium batteries by fire or incineration.
- Do not compact or mutilate lithium batteries to destroy their physical integrity.
- Tape the contacts before disposal of lithium batteries.

LEAD-ACID BATTERY MAINTENANCE

If a device has a battery charger module and lead-acid backup battery, the following considerations are important for maintaining the battery. See "BATTERY CHARGER MODULE" on page 87 for details about the battery charger module.

Avoid Deep Discharge

It is very detrimental to the battery to discharge it to a voltage of less than 10 V. This causes partial destruction of the battery itself. The battery charger module circuitry includes a cutoff circuit to remove the load from the battery when the battery voltage drops below 10.5 V. However, the charger circuitry itself draws a small amount of current from the battery so that prolonged connection (longer than a month) to the charger after the battery has discharged also damages the battery. After a deep discharge, the battery has a reduced cycle life as well as a reduced capacity.

Temperature Effects

The capacity (in ampere hours) of the battery is strongly influenced by the ambient temperature. At lower temperatures the capacity is reduced, and at the lower limit of operation, the capacity is about 50% of that at room temperature. The limits on charging are even greater. The charger includes circuitry to compensate for battery temperature variations, and it attempts to charge outside the ranges shown in Table 21. But at low temperatures the charging is very ineffectual, and at very high temperatures charging may damage the battery.

Table 21. Optimal Battery Temperature Ranges

Function	Range (degrees F)	Range (degrees C)
Discharge	5 to 122	-15 to 50
Charge	32 to 104	0 to 40
Storage	5 to 104	-15 to 40

Battery Replacement

The end of life for a battery may not be obvious. It may have a reduced capacity but otherwise act normally when connected to a charger or load. To avoid device failure due to a dead/reduced capacity backup battery, you should have a battery replacement plan. Your plan should be based on estimating the battery life and then testing the battery capacity and/or replacing the battery within its estimated lifetime.

To estimate the life of a battery, estimate the cycle life and the backup life, and then take the shorter of the two.

Cycle Life

Cycle life the amount of time during which a battery can be discharged and successfully recharged. This number is dependent on the depth of discharge, with a shallow discharge (30%) good for 1200 cycles, and a 100% discharge good for 200 cycles. See Figure 13.

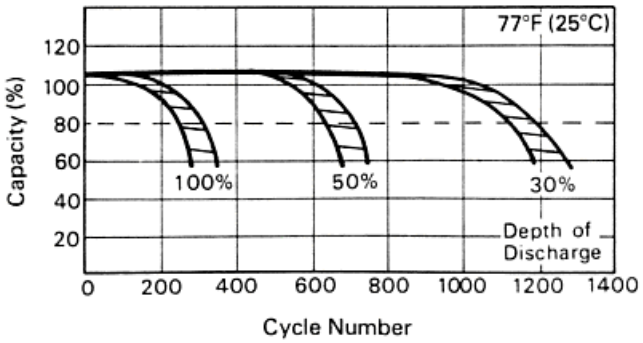


Figure 13. Battery Cycle Life Calculation

To find the cycle life, first estimate the depth of discharge your battery will experience and find the predicted cycles (e.g., 700 cycles based on a 50% discharge). Then divide the predicted cycles by the number discharge/recharge cycles per year that your battery will experience.

Backup Life

Backup life is the amount of time a battery holds its charge when it is kept on a float charger, which is the way the backup batteries in devices are used. The backup life is strongly dependent on temperature and varies from 8 years at room temperature to 1 year at 100 degrees F.

To estimate backup life, first estimate the average temperature and then find the predicted backup life in Figure 14.

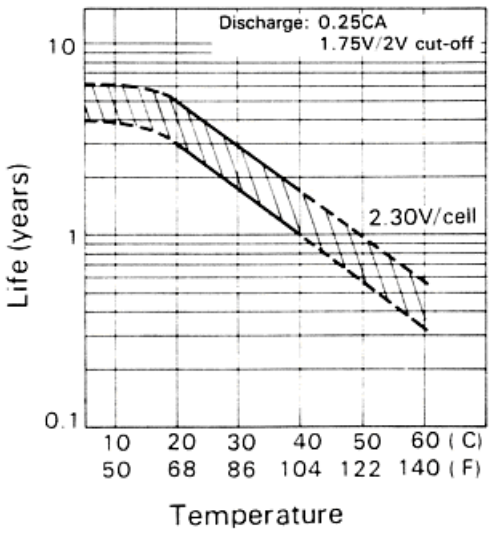


Figure 14. Battery Backup Life Calculation

Storing Backup Batteries

The backup batteries should be stored in a charged state and not be allowed to self-discharge to a low voltage. The time for self-discharge is greater than 1 year at room temperature (see Figure 15). For best results in long-term storage, either charge the battery once per year or keep it on a temperature compensated trickle charger.

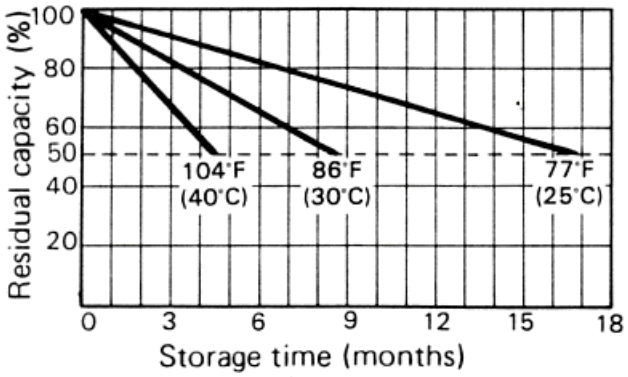


Figure 15. Effect of Temperature on Storage Time

Using the Very Low Battery Charging Option

The battery charger module normally does not attempt to charge a battery with an open circuit voltage of less than 4.5 V. A low open-circuit voltage indicates that the battery has been damaged and has lost a substantial portion of its capacity: normally it should be replaced. Not charging a very low battery prevents the false appearance of a functional battery.

However, the battery charger module provides an option jumper to allow for charging very low batteries. This option is intended to charge batteries that have an open-circuit voltage of less than 4.5 V.

Use the option in applications where the battery is left connected to the charger or another load for an extended period (which causes a very low battery voltage) and where only a fraction of the original battery capacity is needed. In this situation, a battery replacement plan based on time should be implemented to ensure that the batteries function when needed.

CAUTION

For most applications, the option jumper should not be used so the user is forced to replace a damaged battery.

IN CASE OF DIFFICULTY

In case of difficulty, call Zetron (see the front cover of this manual for the phone number). Please have the serial number of the device and/or your Zetron order number. If the call is

made from the installation site by the system integrator or installation technician, the problem can usually be solved over the telephone.

MODULES

This section describes the nine modules. The specifications and a summary of the self-test for each module is also presented. The field wiring subsection for each module shows the label used on the front and/or side of the module along with a description of its various connectors, LEDs, etc.

CORE MODULE

The core module scans the digital I/O, relay output, analog input, and analog output modules once per second.

Input/Output

J2 is a three-wire (RXD, TXD and Ground) RS-232 interface. It is a 9-pin, female D-connector. The pinout is the same as for modems (see "Field Wiring" on page 57). This port is used for direct serial communications with SCADA software or the Configuration Utility.

P3 is a 16450 UART RS-232 interface. It is reserved for connection to the phone modem module or to an off-the-shelf external modem. Since the Model 1730 controller does not use the phone modem, it does not use P3. For the pinout, see "Field Wiring" on page 57.

For communication protocols, the core module relay is treated as core module digital output 5.

Controller RS-232 Watchdog

The Model 1730 controller RS-232 watchdog function allows the controller to turn on a core module output when the PC stops sending messages. The output used is either digital output 4 or the relay output. The output is usually wired to an alarm device like a buzzer or autodialer.

Power Monitoring

Because some of the Model 1730/1732 circuitry runs on the +12 V power supply, and because the hardware reset circuit is connected to the regulated +5 V supply, the firmware monitors the +12 V power and enters a safe mode if it drops too low.

Low power conditions are detected by a comparator on the core module. The output of the comparator goes high when the +12 V power drops below about 9.0 ±0.25 V. When this happens, the firmware enters the safe mode.

In the safe mode, all outputs are set to their power off condition. In other words, all relays are de-energized (including the PTT relay on the radio modem module and the offhook relay on the phone modem module), digital outputs are turned off, and analog outputs set to 0 V.

In safe mode, the firmware shuts down all functions except monitoring the +12 V power and updating the core module LED. That is, it will not continue to monitor inputs, log data, perform local logic, receive polls, transmit exceptions or perform any other normal function.

When the power rises above 9 V again, the firmware will perform a software reset.

The Model 1730/1732 firmware does not monitor the +12 V power supply for overvoltage.

Backup Battery

The core module contains a lithium battery to back up system parameters and logged data. This battery is used only when the system power is off, and it will back up the data for 6 to 24 months.

Replace the lithium battery only with Zetron Part No. 416-0002 or industry type BR2325.

WARNING: DANGER OF EXPLOSION!

- Do not connect the positive (+) and negative (–) contacts of lithium batteries together.
- Do not dispose of lithium batteries by fire or incineration.
- Do not compact or mutilate lithium batteries to destroy their physical integrity.
- Tape the contacts before disposal of lithium batteries.

Specification

8 digital inputs, referenced to ground, weak pull-ups provided (to +12V)

Contact closure to ground or 0-5 V voltage change

Logic Low: <500 ohms or <0.8 V_{dc}

Logic High: >2.5 kΩ or >2.0 V_{dc}

Protected to ±50 V_{dc} through 1 kΩ

Channels 1-5, counting inputs to 1 kHz, duty cycle 40-60%

Channels 6, 7, 8, counting inputs to 0.5 Hz, duty cycle 50%

4 digital outputs: open collector 50 V_{dc}, 100 mA max.

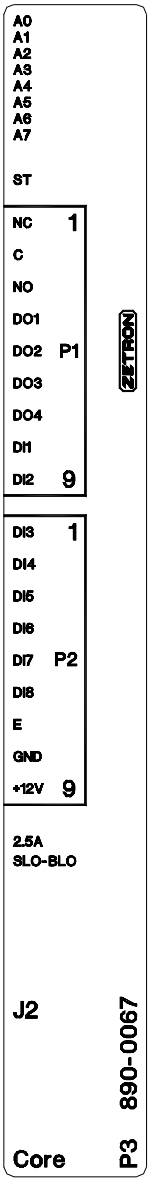
One relay output: Form C contacts: 120 V_{ac} 1 A, 24 V_{dc} 2 A

For equivalent input and output circuits, see Figure 12 on page 43.

Self-Test

The core module does not implement a self-test.

Field Wiring



9406-01C

Module Address

Status LED

Relay Normally Closed
Relay Common
Relay Normally Open
Digital Output 1
Digital Output 2
Digital Output 3
Digital Output 4
Digital Input 1
Digital Input 2

Digital Input 3
Digital Input 4
Digital Input 5
Digital Input 6
Digital Input 7
Digital Input 8
Chassis Ground
Power GND
+12 VDC Power

Fuse for +12 VDC Power

RS-232 (9-pin, female)

Pin	Signal	Meaning	Direction
1	-		
2	TXD	Transmit Data	Output
3	RXD	Receive Data	Input
4	-		
5	Ground		
6	DTR	+10 V	Output
7	-		
8	RTS	+10 V	Output
9	-		

RS-232 (on under side, 9-pin, male)

Pin	Signal	Meaning	Direction
1	-		
2	RXD	Receive Data	Input
3	TXD	Transmit Data	Output
4	DTR	Data Terminal	Output
5	Ground		
6	-		
7	RTS	Ready to Send	Output
8	CTS	Clear to Send	Input
9	RI	Ring Indicator	Input

DIGITAL I/O MODULE

Each digital I/O module provides 16 control or status points.

Each I/O point on the digital I/O module can be configured as either an input or an output.

The core module scans the digital I/O modules at a rate of once per second. Configurable delay times for both the active and inactive states allow for filtering out short duration status changes.

Unlike the digital inputs on the core module, inputs on the digital I/O module do not allow for event counting or run-time accumulation.

When configured as an output, an I/O point can be either latched or momentary mode. For momentary mode, the output turns off automatically after the momentary time expires.

Specification

16 digital inputs/outputs; configured to enable the inputs

Digital outputs: open collector, protected to 50 V_{dc}, 100 mA max.

Digital inputs: referenced to ground, weak pull-ups provided (to +12 V)

Contact closure to ground or 0-5V voltage change.

Logic Low: <500 Ω or <0.8 V_{dc}

Logic High: >2.5 kΩ or >2.0 V_{dc}

Protected to ±50 V_{dc} through 1 kΩ

For equivalent input and output circuits, see Figure 12 on page 43.

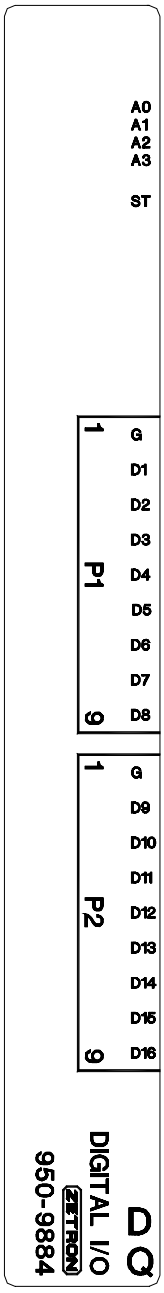
Self-Test

For self-test set up instructions, see “MODULE SELF-TESTS” on page 49.

The self-test for the digital I/O module does a complete test of the I/O of the module. The flash pattern of the status LED indicates the self-test result. The blinking or flashing indicates that the microprocessor is functioning.

Pattern	Result
On and blinking every 2 seconds	Pass
Off and flashing every 2 seconds	Failure

Field Wiring



9406-02A

Module Address

Status LED

GND
DIO 1
DIO 2
DIO 3
DIO 4
DIO 5
DIO 6
DIO 7
DIO 8

GND
DIO 9
DIO 10
DIO 11
DIO 12
DIO 13
DIO 14
DIO 15
DIO 16

RELAY OUTPUT MODULE

Each relay output module provides six form C relay contacts. Each relay can be configured as either latched or momentary. Momentary relays turn off automatically after a user configurable time. The relay output status is scanned by the core module once per second.

Specification

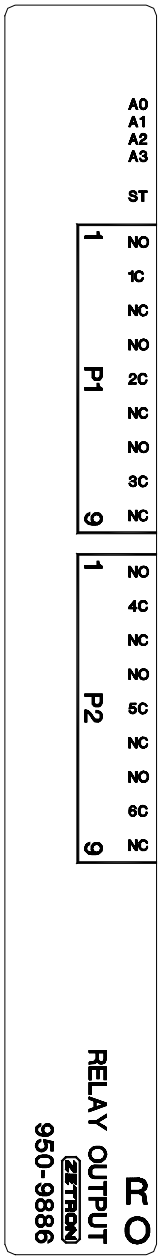
Relay outputs (6 each) Form C contacts: 120 V_{ac} 1 A, 24 V_{dc} 2 A

Self-Test

For self-test set up instructions, see “MODULE SELF-TESTS” on page 49.

The self-test for the relay output module causes the relays to be energized one at a time and left on for approximately 2 seconds. An ohmmeter can be used to measure continuity on the terminal block. A good relay contact should read less than 2 ohms when closed and open circuit when open.

Field Wiring



Module Address

Status LED

Relay 1 Normally Open
Relay 1 Common
Relay 1 Normally Closed
Relay 2 Normally Open
Relay 2 Common
Relay 2 Normally Closed
Relay 3 Normally Open
Relay 3 Common
Relay 3 Normally Closed

Relay 4 Normally Open
Relay 4 Common
Relay 4 Normally Closed
Relay 5 Normally Open
Relay 5 Common
Relay 5 Normally Closed
Relay 6 Normally Open
Relay 6 Common
Relay 6 Normally Closed

9406-03A

ANALOG INPUT MODULE

The analog input module provides eleven 12-bit analog inputs with a -10 to +10V or -40 to +40 mA measurement range. The current range is selected for each input by a push pin jumper on the circuit board which puts a 249 ohm (1%) resistor to ground for that input.

The analog input module is scanned once per second by the core module.

For each input, there are two user definable thresholds, high and low, and one hysteresis setting. An exception report or data logger entry can be generated whenever the input rises above the high threshold or drops below the low threshold. The report will not be sent again unless the input value crosses back over the threshold in the opposite direction by the hysteresis value, then passes the threshold again[iii].

Each input also has settings for generating exceptions or logging when it has changed by a certain percentage from the last reported value. A "debounce" time setting is used to ensure that rapidly fluctuating signals do not cause excessive reports.

These settings are made using the Configuration Utility.

The module provides a buffered output of the internal reference voltage (5.00 volts) and the power input voltage divided by two. The power input voltage divided by two output can be connected to an input and used to monitor the device power. The reference voltage can be used to generate references for sensors.

Analog Accumulator Function

For the analog input module at address 0, each input has an associated accumulator function.

Analog inputs are sampled and the accumulators updated once per second. The core module keeps track of the accumulated total and the number of samples (which equals the elapsed time in seconds). From this, the SCADA program can calculate total accumulated value or average value.

Analog accumulators can be set up to create an exception or log entry when the accumulated value reaches a user-defined value.

The accumulator runs a minimum of 12.1 days before overflow [iv].

[iii] This gives a basic capability equivalent to the Model 1708/Model 1716. Additional thresholds or subranges can be created with the logic function.

[iv] The accumulator is 32 bits, the analog input samples are 12 bits, and the sampling rate is once per second. $2^{32} / 2^{12}$ / (60 sec/min * 60 min/hour * 24 hours/day) = 12.1 days

Specification

Analog Inputs: 11 external.

Input Range: +/-10 V_{dc} single ended, referenced to ground.
–40 to +40 mA current selectable by jumpers on any of the 11 inputs.

Resolution: 12 bits.

Accuracy:

From –20 to –50 degrees C: ±0.7% of reading ±40 mV
At room temperature (25 degree C): ±0.4% of reading ±40 mV
Linearity: ±10 mV or ±2 counts
The module provides a digital filtering of the analog signal.
This is a low pass filter with a cut off of 0.8 Hz.

Load on VR and PM 5 mA maximum

Protected to ±50 V_{dc} through 1 kΩ

For equivalent input and output circuits, see Figure 12 on page 43.

Self-Test

For self-test set up instructions, see "MODULE SELF-TESTS" on page 49. Then connect the test points on the module to a RS-232 connection (see Figure 16).

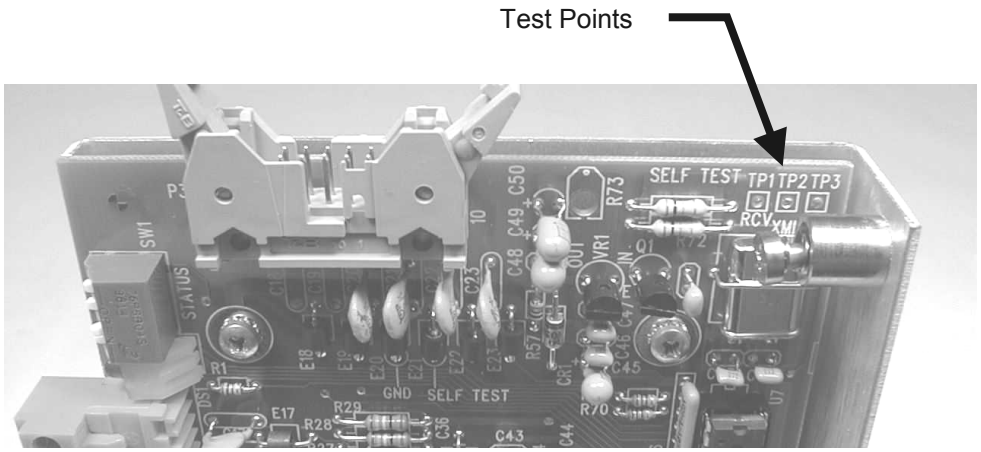


Figure 16. Test Points on Analog Input Module

For connection to a PC, use a 9-pin, Dsub, female connector with the following pinout:

AI Module PCB Label	Signal	Function	DB-9 Pin Number
TP1	RCV	Terminal RCV	2
TP2	XMIT	Terminal XMIT	3
TP3	GND	Terminal GND	5

The communication is 4800 baud, 8 bits, no parity, and 2 stop bits.

The self-test shows the converted values for each input channel on a terminal or PC running a terminal program, such as Hyperterminal. The module outputs formatted text using hex numbers showing the converted value for each input channel. An example of the output is shown below.

```
01 00 04 04 # 0803 0801 07FF 07FF 0803 07FF 0802 07FF 0802 0803
07FF
01 00 04 04 # 0803 0801 07FF 07FF 0803 07FF 0802 07FF 0802 0803
07FF
01 00 04 04 # 0803 0801 07FF 07FF 0803 07FF 0802 07FF 0802 0803
07FF
01 00 04 04 # 0803 0804 07FF 07FF 0803 07FF 0803 07FF 0802 0803
07FF
01 00 04 04 # 0803 0801 07FF 07FF 0803 07FF 0802 07FF 0802 0803
07FF
```

Each line first displays four 2-digit hex numbers followed by the # sign. The first two numbers are the firmware revision, followed by the PCB revision, and then the build version. After the # sign, the converted values from input channel 1 to input channel 11 are displayed. The line is followed by a carriage return and line feed.

The following chart shows hex numbers and the corresponding voltage value.

Hex	Voltage
000	-10 V
400	-5 V
600	-2.5 V
800	0 V
A00	2.5 V
C00	5 V
FFF	10 V

To convert the displayed hex number to voltage, first convert the hex number to decimal. Then use the following equation:

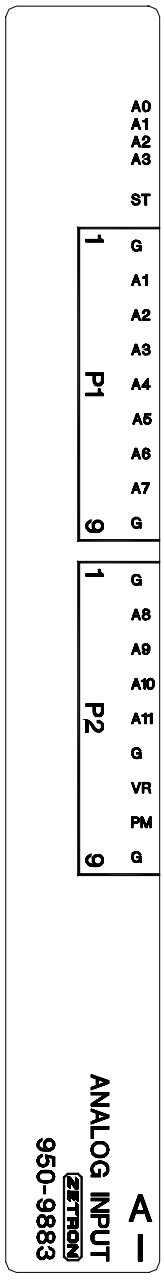
$$\left(\frac{\#(decimal)*20}{4096}\right)-10V = Volt(measured)$$

To convert volts to hex, use the following equation:

$$\left(\frac{Volts}{10}*2048\right)+2048 = Hex(measured)$$

The conversions are repeated at a rapid rate if the DIP switch is set to 0000 and at a slower rate if not.

Field Wiring



9406-04B

Module Address
Status LED
Ground
Analog Input 1
Analog Input 2
Analog Input 3
Analog Input 4
Analog Input 5
Analog Input 6
Analog Input 7
Ground
Ground
Analog Input 8
Analog Input 9
Analog Input 10
Analog Input 11
Ground
Reference Voltage Output (5 VDC, 5 mA max.)
Power Measurement Voltage Output (power_voltage/2) 5 mA max.
Ground

For current measurements, use a push pin jumper on the circuit board at JP1–JP11 to convert 0–5 V to 0–20 mA (see Figure 17).

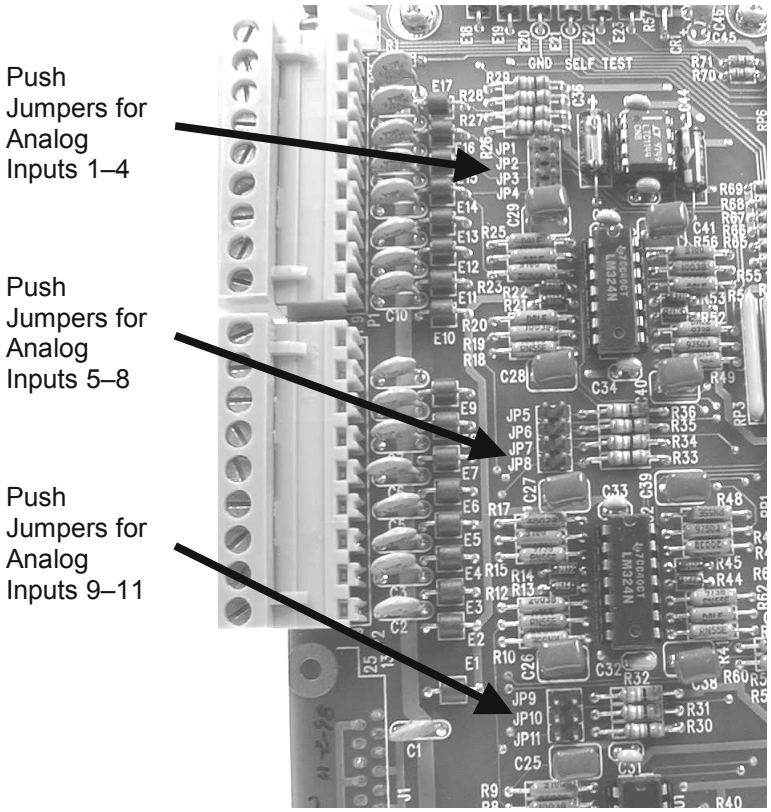


Figure 17. Jumpers on Analog Input Module

ANALOG OUTPUT MODULE

The analog output module provides four separate 8-bit resolution outputs, each of which has both 0-5 V and 0-20 mA connections. The module has a loop voltage generator, which generates a nominal 24 V_{dc} power that can be used to power a 4-20 mA current loop.

The 0-20 mA current outputs require a loop voltage source. The built-in loop voltage generators can be used or an external loop voltage source can be used. An external loop voltage source should be 12-30 V_{dc} and capable of providing 80 mA.

The module loop voltage generator requires a separate power source. This source can be the same nominal +12 V_{dc} powering the system (see "CONNECTING POWER" on page 38). The input circuit is fused. If the loop voltage generator is not needed, the power input to the generator should simply not be connected.

Specification

Analog outputs 4 each - 8 bit DAC

4-20 mA power source provided (24 V_{dc}, 100 mA maximum)

Voltage Output

Single ended referenced to ground. 0-5 V range, +/-5 mA maximum.

Accuracy:	Room temperature	= +/-0.2% of value +/-40 mV
	0-50 degree C	= +/-0.5% of value +/-40 mV

Current Output

0-20 mA current source.

Accuracy:	0-50 degree C	= +/-3.5% of value +/-0.16 mA

Maximum load = 800 ohms

Protected to ±50 V_{dc} through 1 Kohm

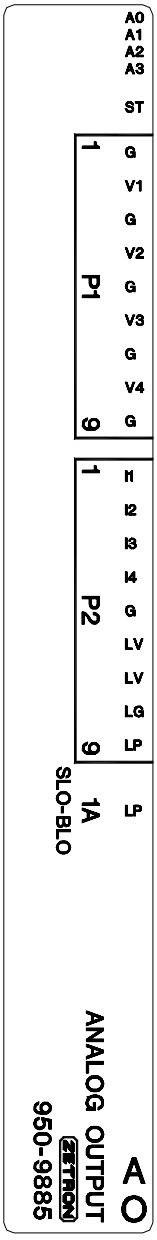
Self-Test

For self-test set up instructions, see "MODULE SELF-TESTS" on page 49.

The self-test for the analog output module causes a voltage ramp on the analog outputs. The voltage will ramp from 0 to 5 V in about 15 seconds and then drop to 0 V and repeat. Each of the four output channels has a different voltage, but they all change at the same time. The current output follows the same pattern with the current ramping from 0 to 20 mA. Note that there must be a loop voltage for the current outputs to function properly although a voltage ramp to a couple of volts can be observed on the current outputs even when there is no loop voltage.

The internal loop voltage generator can be checked by applying +12 V (and GND) power to the loop voltage power input and observing the loop voltage power output.

Field Wiring



9406-05A

Module Address

Status LED

Ground
Voltage Output 1 (0-5 V range)
Ground
Voltage Output 2 (0-5 V range)
Ground
Voltage Output 3 (0-5 V range)
Ground
Voltage Output 4 (0-5 V range)
Ground

Current Output 1 (0-20 mA)
Current Output 2 (0-20 mA)
Current Output 3 (0-20 mA)
Current Output 4 (0-20 mA)
Ground
Loop Voltage, Input or Output, 24 VDC
Loop Voltage, Input or Output, 24 VDC
Loop Voltage Input Power Ground
Loop Voltage Input Power, 12VDC (fused below)

Loop Voltage Input Power Fuse (1 A slow blow)

RADIO INTERFACE MODULE

The radio interface module provides an interface to a radio so that the device can communicate with other devices (Model 1730 controllers, Model 1732 RTUs, and Model 1708 and Model 1716 RTUs).

The module operates with most makes and models of either conventional or trunked two-way radios.

Multiple devices, including Zetron Models 1700, 1708, and 1706, can be connected to the same radio, using the TXREQ line on the radio connector to arbitrate radio access.

The radio interface module can be put into a test mode that causes it to key up the radio and transmit a test tone. This is used during installation and adjustment of the audio signals (see "Audio Levels" on page 74).

For data transmissions over long distances, the radio interface module can be connected to dedicated leased phone lines (for set up instructions, see "Connecting the Module to a Dedicated Leased Line" on page 76).

In addition to the status LED, there are two LEDs on the module that indicate when the module is transmitting and when the carrier detect (COR) signal from the radio is active.

Store and Forward

Sometimes a controller and RTU are out of radio range of each other, but are both within range of an intermediate RTU. In this case, they can communicate indirectly using the store and forward feature of the intermediate RTU (see Figure 18).

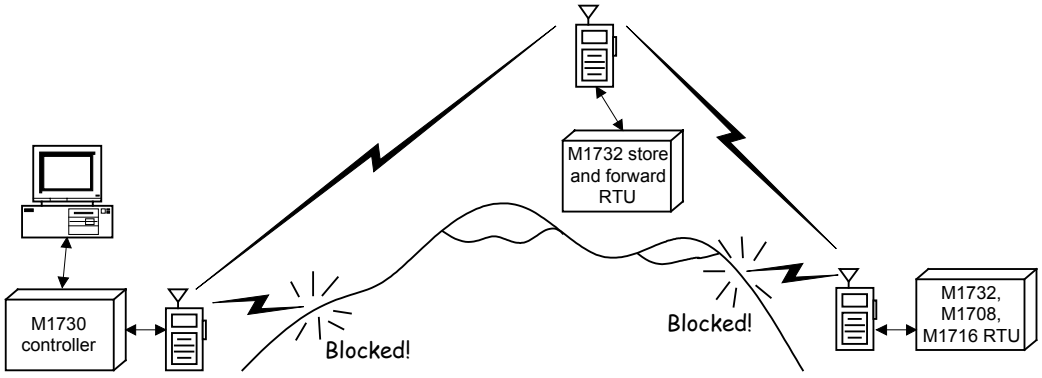


Figure 18. Using the Store and Forward Function to Complete Communications

The intermediate RTU[v] receives all messages transmitted by either the controller or the distant RTU. When it receives a message, it looks in its store and forward table to see if the

[v] The intermediate RTU must be a Model 1732. Models 1708/1716 cannot store and forward for an out-of-range Model 1732.

message should be forwarded. If so, it replaces the addresses in the message and re-transmits it.

The RTU has 10 separate store and forward control blocks that determine which messages should be forwarded. Each control block contains six values:

- Low outbound address range
- High outbound address range
- Outbound address offset
- Low inbound address range
- High inbound address range
- Inbound address offset

Every radio message contains both a source address and destination address. When a message is received by the store and forward RTU, it looks at the addresses and forwards the message as shown in Table 22.

Table 22. Store and Forward Determination

Condition (Addresses Received)	Resulting Action
If destination address is in the inbound range **And** source address is in the outbound range	**Then** add the outbound offset to the source address, add the inbound offset to the destination address, and re-transmit the message
If source address minus the inbound offset is in the inbound address range **And** destination address minus the outbound offset is in the outbound address range	**Then** subtract the inbound offset from the source address, subtract the outbound offset from the destination address, and re-transmit the message

Usually, there is only one store and forward RTU between the controller and the most distant RTU. However, some systems may be more complicated and require multiple "hops" to reach some RTUs. The store and forward feature is flexible enough to allow for this.

Example

Figure 19 illustrates the store and forward function.

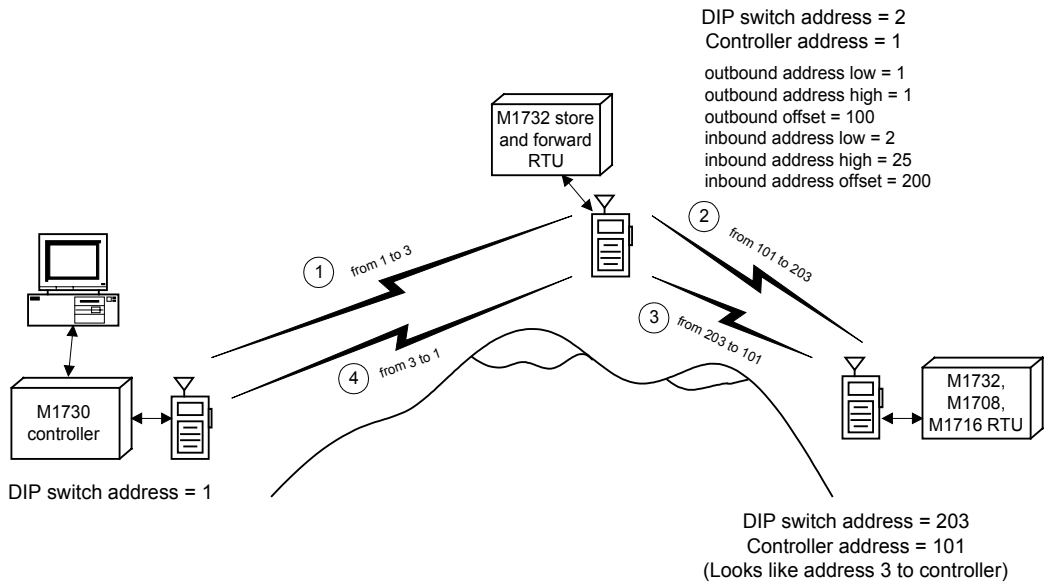

DIP switch address = 2
Controller address = 1
outbound address low = 1
outbound address high = 1
outbound offset = 100
inbound address low = 2
inbound address high = 25
inbound address offset = 200
M1732 store and forward RTU
1 from 1 to 3
2 from 101 to 203
3 from 203 to 101
4 from 3 to 1
M1730 controller
DIP switch address = 1
M1732, M1708, M1716 RTU
DIP switch address = 203
Controller address = 101
(Looks like address 3 to controller)

Figure 19. Example of Store and Forward Function

In Figure 19, the controller's radio can reach the RTU at the top of the mountain, but not the RTU on the other side of the mountain. The RTU on top of the mountain can reach both the controller and the other RTU, so it is configured to do store and forward. From the controller's point of view, the two RTU addresses are 2 (the store and forward RTU) and 3 (the RTU on the other side of the mountain).

When the controller sends a poll message ① to address 3, the store and forward RTU receives it and checks to see if it should be forwarded. This message meets the first condition in Table 22, so the outbound offset is added to the source address and the inbound offset added to the destination address and the packet re-transmitted ②.

The message addressing is now from address 101 to address 203. 203 is the actual DIP switch address of the RTU on the far side of the mountain, and it is configured to respond to controller address 101, so it accepts this message and responds to it ③.

The store and forward RTU receives the poll response which is addressed from 203 to 101. The second condition in Table 22 is met, so the inbound offset is subtracted from the source address and the outbound offset subtracted from the destination address. The packet is re-transmitted by the store and forward RTU ④ with source address 3 and destination address 1. The controller receives the response.

Limitations

Store and forward should be used only when direct communications between the controller and RTU are impossible or impractical. Consider the following limitations before using store and forward in your system.

- The chance of communications failures is increased because the store and forward process increases the number of transmissions required for each transaction between the controller and an out of range RTU.

- Since the number of transmissions is increased in a store and forward system, the load on the radio channel is greater than in an equivalent system that does not use store and forward.

- The additional transmissions required to communicate through a store and forward RTU decrease the responsiveness of the whole system. It may take 8 seconds to communicate with an RTU through store and forward and only 4 seconds with a direct radio connection.

- A store and forward RTU can only forward one message at a time. If additional messages are received by the store and forward RTU while it is waiting for access to the radio channel, they will not get forwarded.

- Store and forward RTUs do not do retries of forwarded messages. Retries are the responsibility of the controller or RTU that originally sent the message. If a message is lost at any point in a transaction between a controller and RTU, the transaction must be redone from the beginning.

Connecting the Module to a Radio

Installation of a radio consists of connecting the radio interface module to the radio, making the option selections on the module, and adjusting the levels to match the radio.

Device Settings

The default device settings are suitable for most systems, but some settings may need to be changed for your radio. The settings in Table 23 are changed using the Configuration Utility.

Connections, Options, and Adjustments

The radio interface module connects to the device using the expansion bus and connects to the radio with the 10-pin connector (P3) located on the front of the radio module. DIP switches and potentiometers on the front of the module select various options and modes, and they set signal levels for the radio interface. The radio connector is the same as the one used in Zetron's Model 1700, Model 1708 and Model 1716.

Table 23. Device Settings for Radio

Setting	Range	Default	Comment
Channel Busy Delay	0 to 250 x 0.1 s	10 (1 second)	
Key Up Delay	0 to 250 x 0.1 s	5 (0.5 seconds)	
Key Down Delay	0 to 250 x 0.1 s	1 (0.1 seconds)	
Acquisition Time-out	5 to 250 s	30 seconds	This is the time-out for the first two steps of radio transmission - radio contention via the TXREQ signal and channel busy detect via the COR signal.
Inter Packet Delay	0 to 250 x 0.1 s	5 (0.5 seconds)	This is the minimum delay between the time the radio is keyed down at the end of a transmission and the beginning of key up sequence for the next transmission.

Connecting Power to the Radio

The radio interface module provides terminal block and fusing for powering a low powered radio (up to 2 A). The power can be wired to the P2 terminal block, fused and provided on the pins 1 and 2 of the radio connector P3. Power can also be provided separately to the radio without going through the radio interface module. Some DIP switch options require a connection to the radio power even if the radio power is not provided through the radio connector P3, so it is recommended to connect both GND and +12V from the radio to the radio connector on the module.

PTT Options

PTT — PTT is a relay contact that turns the radio on. It is energized when the module wants the radio to power up. The radio may require an isolated contact for this function (use PTT_O and PTT_C) or it may use a single input (use PTT_O). It has several options that are selected by the DIP switch on the face of the module (see “Field Wiring” on page 79).

PTT-PU PU — PTT Pull Up. This switch determines what the PTT line is connected to while it is de-energized. When this switch is on, a 10K ohm resistor is connected from the radio power pin to PTT while de-energized. When this switch is off, PTT is open while de-energized. This switch would be used when the radio requires a PTT off state to be connected to +12V and does not have its own pull up.

PTT-GND PG PTT-to-ground. This switch determines what the PTT line is connected to when it is energized. When this switch is on, it connects PTT_C to GND. When this switch is off, the PTT_C line must be wired to the radio.

Trunked/Nontrunked Options

The difference between a trunked and non-trunked radio is in the method of seizing the radio.

For a non-trunked radio, COR is tested until the radio is not busy (COR off) and then the PTT is energized and the module begins to transmit.

For a trunked radio, PTT is energized and then COR is tested for not busy. When COR goes to not busy, the module begins to transmit.

TRUNK TY Trunking radio. When this switch is on, it selects the trunked radio mode. When this switch is off, it selects the non-trunked radio mode.

COR Options

The COR (carrier detect) allows the module to know when the radio is receiving information from another radio or when a channel is available for a trunked system. The COR valid signal (LED on) indicates that the radio is busy.

There are many different methods to develop this signal. The radio interface module has options and adjustments to allow connections to most radios.

COR-POL CP COR Polarity. This switch allows the module to change the sense of the COR signal. On means a signal lower than the threshold activates COR. Off means a signal higher than the threshold activates COR.

COR-ADJ CA COR threshold is adjustable. On allows the COR_ADJUST_POT to vary the threshold. Off uses fixed threshold of 2.5 V.

COR-PD CD COR is pulled down to ground. On adds a 20K ohm resistor to ground on the COR signal.

COR-PU CU COR is pulled up to radio power. On adds a 20K ohm resistor to the radio power on the COR signal.

COR CO This pot is used to adjust the COR threshold when the COR-ADJ switch is on.

Audio Levels

The audio levels must be adjusted to match the radio. Both transmit and receive levels are adjusted using a single turn pot and a gain switch. In addition the

receive path must select the frequency response between flat and discriminator outputs.

FLAT	RF	On selects a flat frequency response for the receive audio. Use this switch when the radio outputs from its speaker or audio circuitry. When this switch is on, the DISK (RD) switch must be off.
DISK	RD	On selects a de-emphasized frequency response for the receive audio. Use this switch when the radio outputs from its detector circuits and is not de-emphasized. When this switch is on, the FLAT (RF) switch must be off.
TX*1	T1	Transmit Gain Select. On for gain times 1. Off for gain times 10.
RX*1	R1	Receive Gain Select. On for gain times 1. Off for gain times 10.
TEST	TS	On for test mode. Use this switch to cause a signal to be sent to the radio in order to adjust levels. Off for normal operation.

Turning the TEST (TS) switch on causes the module to turn the radio on and send signals. Use the TX*1 (T1) switch and the XMIT (TX) potentiometer to adjust the signal level at TP2 (TX AUD) to the levels that meet the radio manufacturer's specifications.

The receive audio is adjusted using the RX*1 (R1) switch and the RCV (RX) potentiometer to obtain a signal at TP1 (RX AUD) of 1.5 Vpp.

When adjusting audio levels, do not leave the radios transmitting continuously as this can harm some radios. The test tone automatically turns off after 60 seconds. To restart the test tone, the test switch must be turned off and then back on.

Note

The test mode is controlled by firmware in the core module. For the test mode to function, the core module must have the correct firmware loaded.

Connecting Several Devices to a Single Radio

The TX_REQUEST line is used by the radio interface module (and Zetron Models 1700, 1708, and 1716) to share a single radio between several RTUs or controllers. All TX_REQUEST lines between the modules/devices that are sharing a radio should be tied together. The modules/devices then automatically share the radio by waiting until the radio is not in use to seize the radio. This function is always active but has no effect unless two or more modules are sharing a radio.

Note that each module/device must set its own audio levels for transmit and receive and use the same options for other radio functions. All modules and devices must be wired to the radio in a parallel manner.

Connecting the Module to a Dedicated Leased Line

The controller and an RTU can be connected using a dedicated leased line with the radio interface module providing the interface.

To set up the interface between the radio interface module and the dedicated leased line, use the diagram in Figure 20.

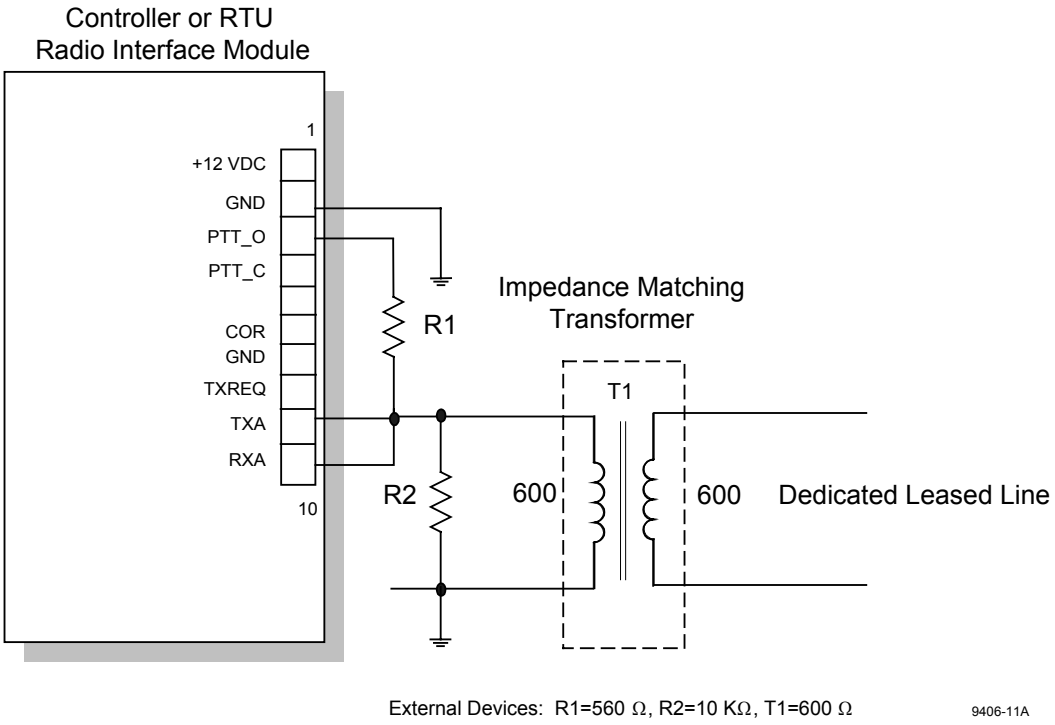


Figure 20. Dedicated Leased Line Interface

Make the following DIP switch settings:

PTT-PU	PU	PTT Pull Up. Turn off.
PTT-GND	PG	PTT to ground. Turn on.

Data Collisions

There is no data flow control provided in the transformer coupling. If a busy indication is available, connect it to the COR input (pin 6 of P3) on the radio interface module. If a busy indication is not available, make the following DIP switch settings:

COR POL	CP	COR polarity. Turn off.
COR-ADJ	CA	COR threshold adjustment. Turn off.
COR-PD	CD	COR is pulled down to ground. Turn on.
COR-PU	CU	COR is pulled up to radio. Turn on.

Amplification

Because attenuation is high on simple copper-pair wire, use line drivers for transmissions over long distances. However, leased lines from the phone company should not require external amplification devices. Adjust the signal amplitude to the levels required by the phone company using DIP switch TX*1 (T1), RX*1 (R1) and potentiometers XMIT (TX) and RCV (RX).

Signal Loss

Signal loss will result from:

- Improper grounding - Make sure the interface is grounded properly (see Figure 20).
- Using the wrong type of transformer - Make sure your unit is a balanced 600 Ω transformer (available from Zetron, Part No. 305-0022).
- Using incorrect resistor values - Make sure R1 is 560 Ω, and R2 is 10 kΩ.

Specification

Input levels	from 50 mV to 5 Vpp, adjustable with two gain ranges
Input impedance	> 50 kΩ at 1 kHz
Output level	50 mV to 5 Vpp, adjustable with two gain ranges
Output impedance	< 700 Ω at 1 kHz
Settings	PTT, COR, flat TXAUD, flat RXAUD and ground
Audio out	Flat
Audio in	Flat and pre-emphasized (audio and discriminator outputs)
COR	Adjustable from 0.1 to 4.5 V_{dc}
PTT output relay	< 300 mA max., normally open contacts or contact to ground Protected to ±50 V_{dc} through 1 kΩ

Self-Test

For self-test set up instructions, see “MODULE SELF-TESTS” on page 49.

The self-test for the radio interface module causes the PTT relay to close and send an audio test pattern for about 5 seconds. The relay opens for about 1 second and the pattern repeats. All other functions, including COR detection, gains, etc., function normally.

Bench Test

For a bench test of a controller and RTU with radio interface modules but without actual radios, use the following connections and settings. The devices must be less than 20 feet apart.

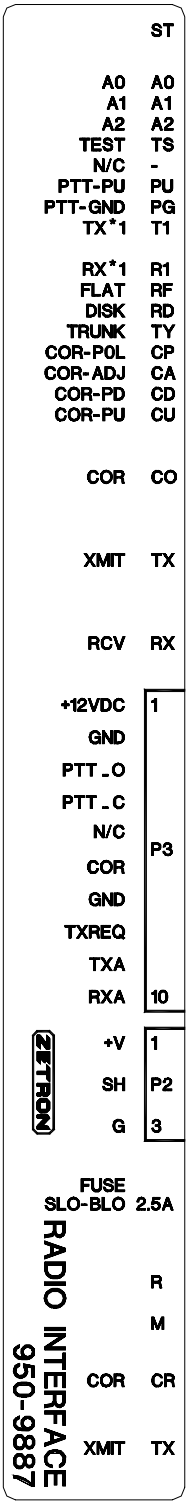
Connect the Radio Interface module P3 connector RX of one device to the Radio Interface module P3 connector TX of the other device.

Device A Radio Interface Module P3 Connector			Device B Radio Interface Module P3 Connector
Pin 10	RXA	→	Pin 9 TXA
Pin 9	TXA	→	Pin 10 RXA

Make the following settings to the switches and potentiometers:

A0	Turn on.
A1	Turn on.
A2	Turn on.
TS	Turn off.
-	Turn off.
PU	Turn off.
PG	Turn off.
T1	Turn off.
R1	Turn on.
RF	Turn on.
RD	Turn off.
TY	Turn off.
CP	Turn off.
CA	Turn off.
CD	Turn on.
CU	Turn on.
CO	This potentiometer is not used.
TX	Adjust the TX potentiometer for a level of 1.5 V_{pp} at TP2.
RX	Adjust the RX potentiometer for a level of 1.5 V_{pp} at TP1.
P3-9	Connect to RXA of the other device.
P3-10	Connect to TXA of the other device.

Field Wiring



9406-06C

Status LED

Address Switch A0
Address Switch A1
Address Switch A2
Puts the module into test mode
Not connected
Push to Talk pull up
Push to Talk to Ground
Transmit Level Gain = 1

Receive Level Gain = 1
Receive Filter Response = Flat
Receive Filter Response = Discriminate
Trunking Radio
COR Polarity is positive to disable radio
COR threshold is adjustable
COR is pulled down to Ground
COR is pulled up to radio power

COR Level Adjustment

Transmit Level Adjustment

Receive Level Adjustment

Radio Connector	+12 VDC	Fused to P2
	Ground	
	PTT Out	
	PTT Com	
	N/C	Not connected
	COR	Input to radio interface module
	Ground	
	TXREQ	Used to share the radio with multiple devices
	TXAUD	Output from radio interface module
	RXAUD	Input to radio interface module
External Radio Power	+V	Radio power: 11-16 VDC
	SH	Shield, connects to chassis
	Ground	Common to system ground

External Radio Power Fuse (2.5 mA max.)

Auxiliary Audio (Not used)

Auxiliary Audio (Not used)

Green Carrier Detect LED

Red Radio Transmit LED

PHONE MODEM MODULE

The phone modem module is a 2400 baud AT command set modem. It provides automatic line seizure, and it can share the phone line with another device. The module has two RS-232 connectors: P2 and J2. J2 is a standard DB25 connector, and it is not used. P2 is a 5-pin latching connector, and it is used to connect the phone modem module to the core module.

The Zetron-supplied cable (Part No. 709-7486) connects P2 on the phone modem module to P3 on the core module.

A standard 6-conductor telephone cable with a RJ11 modular plug connects the phone modem module's telephone port (F1 on the label, J1 on the PCB) to the phone line.

Specification

General

2 wire (Tip/Ring) RJ11 connector

ringer equivalents	0.45 B
maximum voice power output to PSTN	-10 DBMS
maximum DTMF power output to PSTN	-1 dBm
DTMF signal	100 msec on/100 msec off

Serial Communication Port, RS-232 (P2 or J2)

Data Rate	300, 1200, or 2400 baud
Bits	7 or 8
Parity	None, Even, Odd
Stop Bits	1
Input Protection	+/- 30 V_{dc}

Telephone Port (F1 on label, J1 on PCB)

Connector	6 conductor modular

Dialingtone or pulse

Modem

Baud rate	300, 1200, or 2400 baud
Format	Bell 212A 1200 baud Bell 103 300 baud AT command set listed in Table 24 to Table 27.

Table 24. AT Commands Supported

Command	Description	Options	Default
A/	Repeats last command line		
A	Answer		
DP	Pulse dial a phone number		
DS=*n*	Dial the string specified by n (string is entered with &Zn=s command)	0-3	
DT	Touch tone dial a phone number		
E*n*	Command echo	0 = off, 1 = on	1
H*n*	Hook status	0 = off, 1 = on	
I*n*	ID code	0 = Product code (249) 1 = ROM checksum 2 = Checksum test 3 = Product revision 4 = Software copyright	
O*n*	Online/retrain mode	0 = Return online 1 = Return online with retrain 2 = Enable automatic retrain 3 = Disable automatic retrain	2
Q*n*	Quiet result	0 = off, 1 = on	0
R	Reverse originate		
S*r*=*n*	Set S register	See Table 25	
S*n*?	Return value in register n	See Table 25	
V*n*	Verbose result	0 = off, 1 = on	1
X*n*	Result code	See Table 26	4
Y*n*	Enable long space disconnect	0 = disable, 1 = enable	0
Z*n*	Restore from non-volatile memory	0 or 1	
&C*n*	Carrier detect override	0 = on, 1 = normal	0
&D*n*	DTR mode	0 = Ignore DTR 1 = Go to command state if ON to OFF detected 2 = Go to command state and disable auto answer if ON to OFF detected 3 = Initialize modem with EEPROM if ON to OFF detected	0
&F	Restore to factory configuration		
&P*n*	Pulse dial timing	0 = U.S., 1 = U.K.	0
&S*n*	DSR override	0 = U.S., 1 = U.K	0
&T*n*	Test mode	See Table 27	
&V	View active configuration and user profiles		
&W*n*	Write current configuration to EEPROM	0 or 1	0
&Yn	Designate default user profile	Z0 or Z1	
&Zn=s	Store a phone number	n = 0-3; s = string for dialing a phone number 0-9,#,* = phone number digits , = delay (see S8 register in Table 25) ; = return to command mode @ = silent answer ! = flash W = wait for dial tone R = reverse mode	

Note: n represents an assigned value, r represents the number of the register, s represents a string

Table 25. S Registers Supported

Reg.*	Function	Units	Default
S0	Answer on ring	No. of rings	000
S1	Ring counter	No. of rings (up to 8)	000
S2	Escape code	ASCII value	043 (+)
S3	Carriage return	ASCII value	013 (CR)
S4	Line feed	ASCII value	010 (LF)
S5	Back space	ASCII value	008 (BS)
S6	Wait for dial tone	Seconds	002
S7	Wait for carrier	Seconds	030
S8	Pause time	Seconds	002
S9	Carrier valid	100 milliseconds	006
S10	Carrier drop out	100 milliseconds	014
S11	DTMF tone duration	1 millisecond	070
S12	Escape guard time	20 milliseconds	050
S18	Test timer	Decimal # 0-255	000
S25	DTR delay	10 milliseconds	005
S26	CTS delay	10 milliseconds	001

* Register is stored in EEPROM with &W command.

Table 26. Result Codes

Verbose	Numeric	X0	X1	X2	X3	X4
OK	0	✓	✓	✓	✓	✓
CONNECT	1	✓				
CONNECT 300	1		✓	✓	✓	✓
CONNECT 1200	5		✓	✓	✓	✓
CONNECT 2400	10		✓	✓	✓	✓
RING	2	✓	✓	✓	✓	✓
NO CARRIER	3	✓	✓	✓	✓	✓
ERROR	4	✓	✓	✓	✓	✓
NO DIAL TONE	6			✓		✓
BUSY	7				✓	✓

Table 27. Test Modes

Command	Test Mode
&T0	End/Abort test
&T1	Initiate local analog loopback test
&T3	Initiate local digital loopback test
&T4	Permit remote digital loopback
&T5	Prohibit remote digital loopback
&T6	Initiate remote digital loopback
&T7	Initiate remote digital loopback with self-test and error detector
&T8	Initiate local analog loopback with self-test and error detector

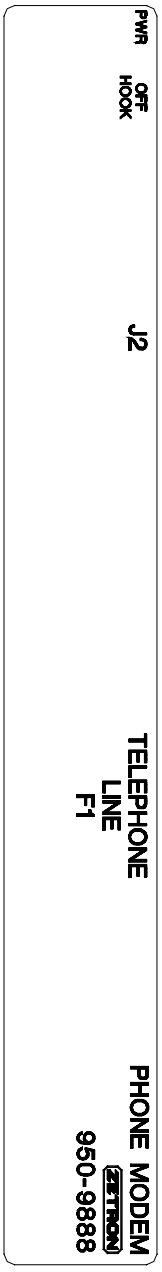
The factory-set modem configuration is:

E1 Q0 V1 X4 Y0 &C0 &D0 &P0 &Q0 &R0 &S0 &Y0
S00:000
&Z0=
&Z1=
&Z2=
&Z3=

Self-Test

The phone modem module does not implement a self-test.

Field Wiring



9406-07A

Green Power LED

Red Off Hook LED

DB25 Connector (Not used)

P2 5-pin RS-232 Connector

Pin	Signal	Meaning	Direction
1	RTS	Request To Send	Input
2	RXD	Receive Data	Input
3	Ground		
4	TXD	Transmit Data	Output
5	CTS	Clear To Send	Output

RJ11 Phone Line Connector

AC POWER MODULE

The AC power module converts 110 V_{ac} power into 16 V_{dc} power that can be used to power the entire device. It provides a protected terminal block for AC power input, a power switch, and a fuse for the AC power in. It provides a terminal block for DC power output. LED status lights are provided for both AC power in and DC power out.

When used with a battery charger module, the voltage output is further regulated by the charger circuits to provide a nominal 12 V to power the device. When used without a charger, the 16 V_{dc} can be used directly by the core module.

CAUTION

Fasten the AC power module to the backplane *before* connecting the AC power and protective ground.

The AC power connection must include three connections: line, neutral, and protective ground. The AC power wires must be strapped to the module using the tie wraps provided in the bagged kit for the AC power module.

The AC power module has a fuse and a single pole switch for disconnecting the AC power from the device. To protect against excess current, short circuits, and earth faults in the circuits before the fuse and switch, you must insert a disconnect in the wiring to the AC power module. A single pole disconnect may be used unless neutral in the primary supply cannot be reliably identified.

When an AC power module is replaced, first disconnect the AC power from the device.

Specification

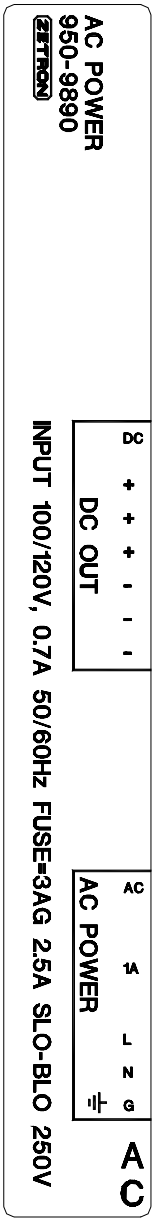
Power input AC power at 100-120 V, 0.7 A max.

Power output 16 V_{dc} at 2 A

Self-Test

The AC power module does not implement a self-test.

Field Wiring



DC Output Status LED
+16 VDC, 2 A max.
+16 VDC, 2 A max.
+16 VDC, 2 A max.
Ground
Ground
Ground

AC Input Status LED

AC Input Fuse (2.5 A slow blow)

AC Input Power, Line
AC Input Power, Neutral
Safety Ground, connected to chassis

9406-08B

BATTERY CHARGER MODULE

The optional battery supplied with this module is a sealed lead-acid rechargeable battery. The rechargeable battery function is a chemical reaction and is influenced by the environment in which it is used, including temperature, charging methods, and discharge rates. The factors that affect the use of the battery are discussed in "LEAD-ACID BATTERY MAINTENANCE" on page 50.

The battery charger module provides a two-step float battery charger: a bulk charge followed by an overcharge. Once charged, it maintains a float charge on the battery. The charger is temperature compensated to maintain the proper voltage levels over the operating temperature ranges.

For information about the option jumper for charging very low batteries, see "LEAD-ACID BATTERY MAINTENANCE" on page 50.

Specification

Input Voltage	15.5 to 17.5 V_{dc}, 2 A maximum
Charging Operating Temperature	0-40 degree C (note the battery will not be charged outside of this temperature range)
Capacity	Combined battery charge current and load current 2A max without drawing from the battery.
Max Load (from Battery)	8 A (fused)

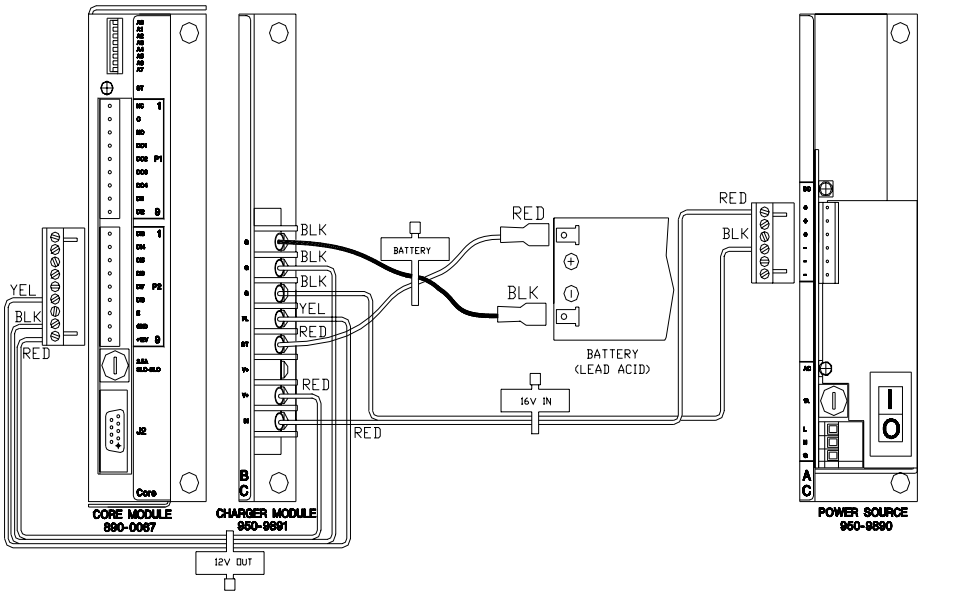
Load will be disconnected from battery when battery voltage is less than 10.5 V.

Typical Charge Time for 7 AH Battery	4-8 hours

Self-Test

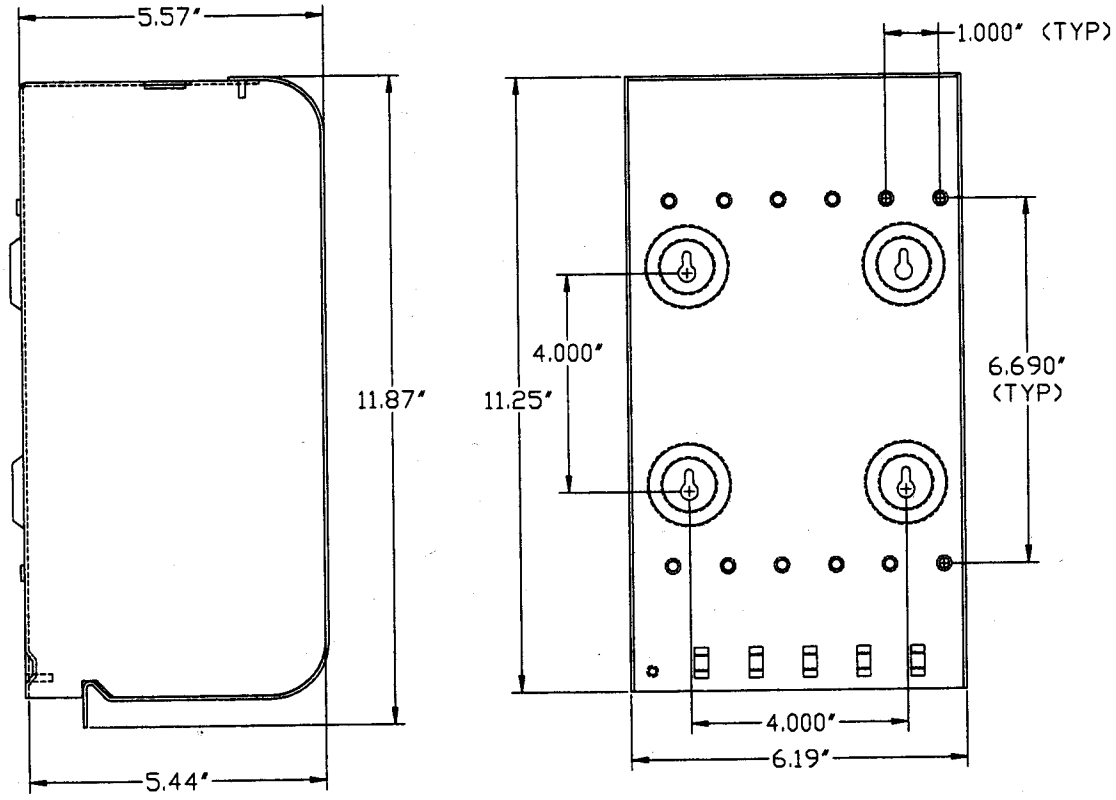
The battery charger module does not implement a self-test.

Field Wiring



APPENDIX A — MOUNTING ENCLOSURES

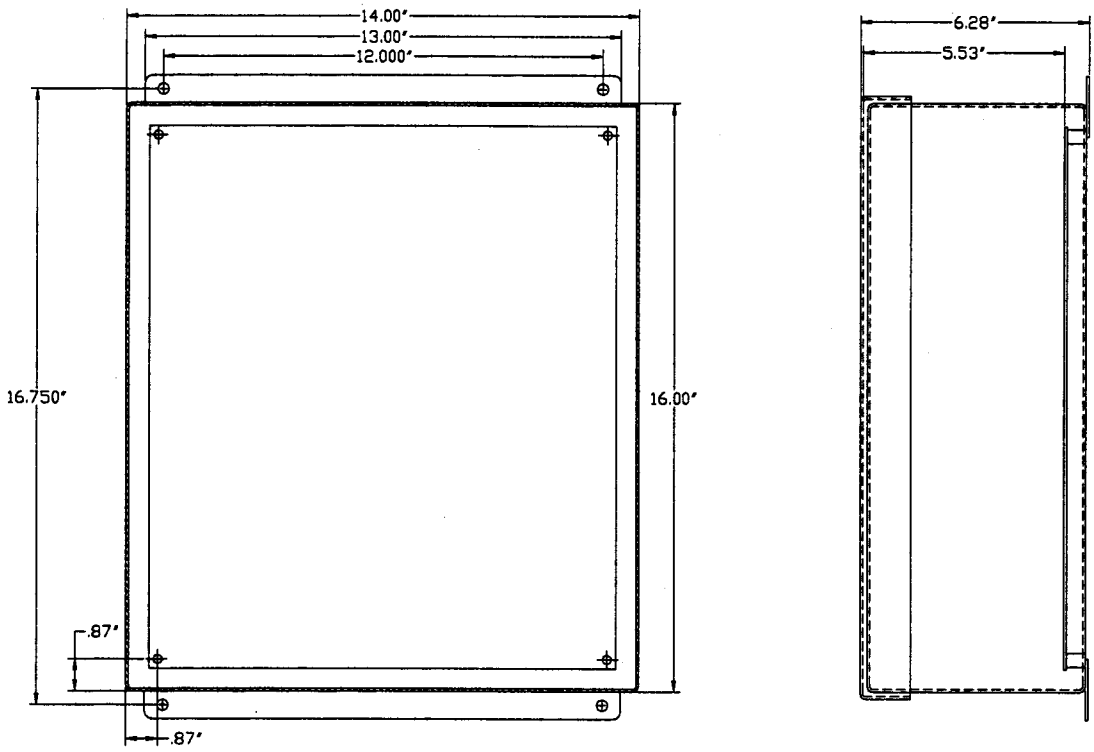
ZETRON BOX



Z-BOX
(415-0231)

024-0298A

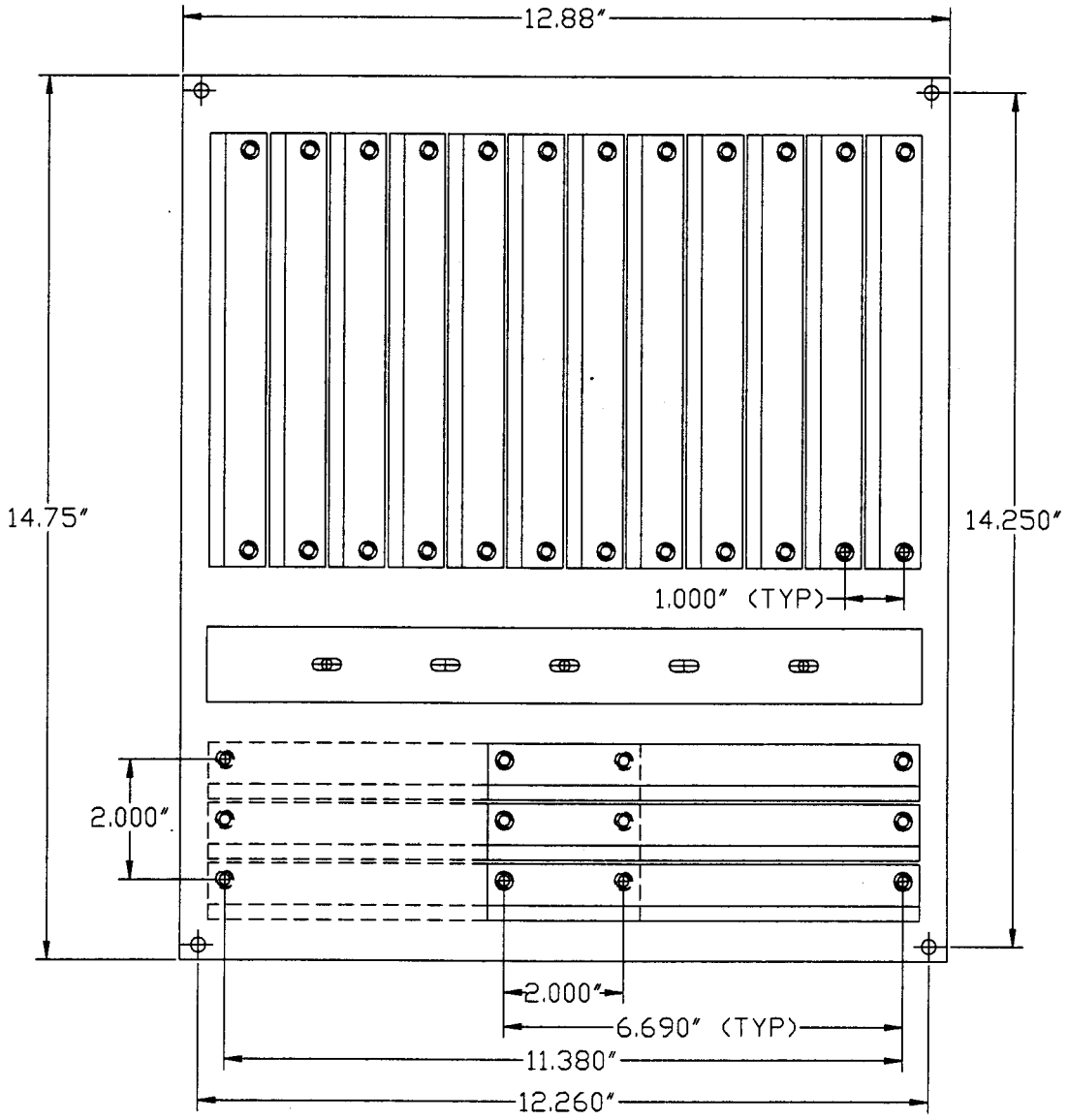
MEDIUM NEMA ENCLOSURE



MEDIUM NEMA ENCLOSURE (STEEL/FIBERGLASS)
(810-0086/810-0087)

024-0298A

MEDIUM NEMA MOUNTING PLATE

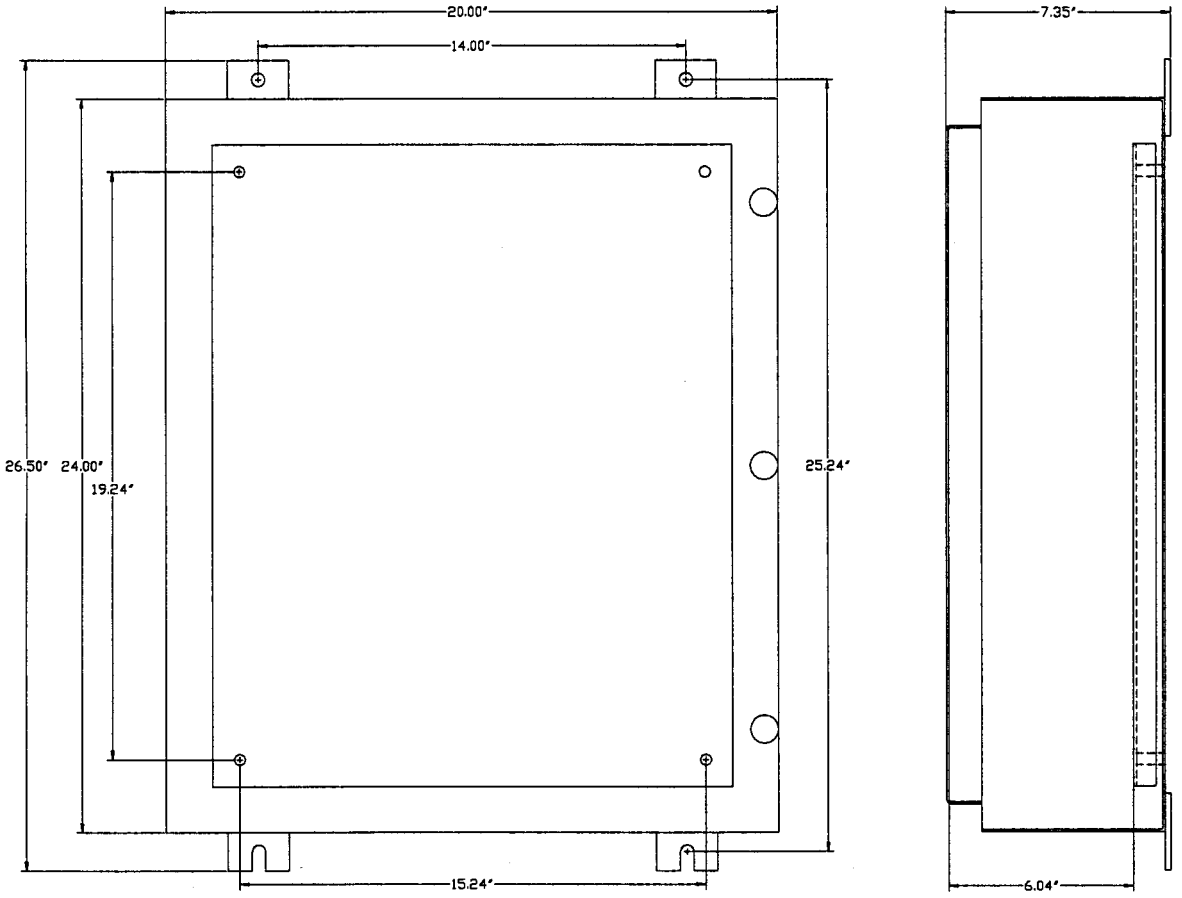


MEDIUM NEMA PLATE (415-0234)

NOTE: VERTICAL CLEARANCE 5.50″ MIN.

024-0302A

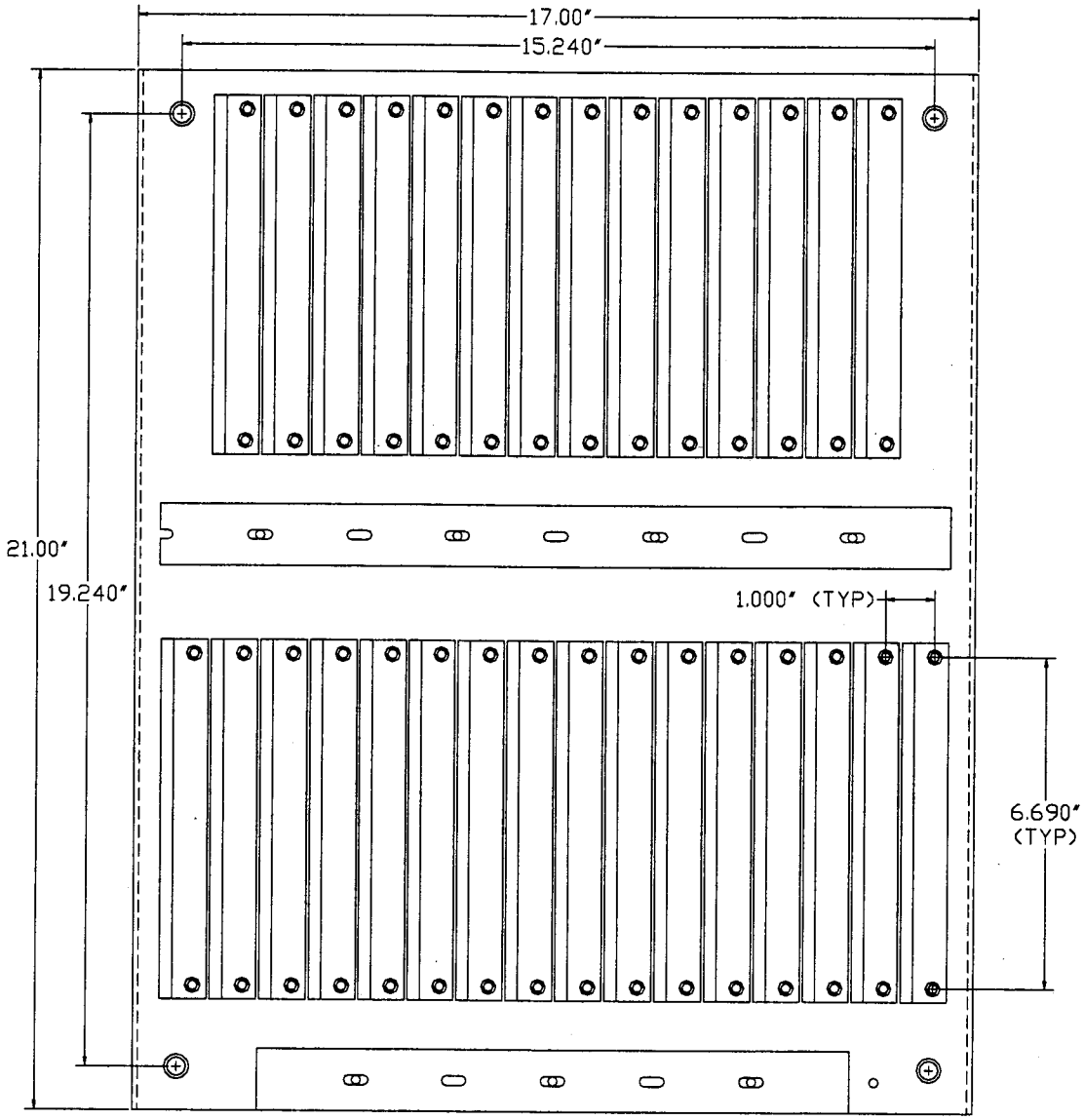
LARGE NEMA ENCLOSURE



LARGE NEMA ENCLOSURE
STEEL/FIBERGLASS
(810-0075/810-0077)

024-0301A

LARGE NEMA MOUNTING PLATE



LARGE NEMA PLATE (415-0318)

NOTE: VERTICAL CLEARANCE 5.50" MIN.

024-0300A

APPENDIX B — COMMUNICATIONS & I/O TEST PROGRAM

The Model 1730 - Model 1732 Communications And I/O Test program is a troubleshooting tool for the Model 1730 Controller and Model 1732, Model 1716 and Model 1708 RTUs. With it you can:

- verify or debug radio communications between the M1730 Controller and RTUs
- verify proper wiring of Controller and RTU i/o points to equipment
- verify that i/o points on the Controller and RTUs are configured properly
- monitor the operation of an RTUBASIC program running in a M1732 RTU by watching changes in the RTUs inputs and outputs

STARTING THE PROGRAM

The setup process adds the program "M1730-M1732 Comm And I/O Test" to your Windows Start menu in the "Programs\Zetron\M1730-M1732 Comm And I/O Test" group. Select this menu item to start the test program. If the setup process created a shortcut on your desktop, you may also double click on this icon to start the program. The main window is shown in Figure 21.

To use the test program, you must connect one of your PC's RS232 ports to connector J2 on the Model 1730 controller or Model 1732 RTU. Use the same cable that you use to configure the Model 1730 or Model 1732.

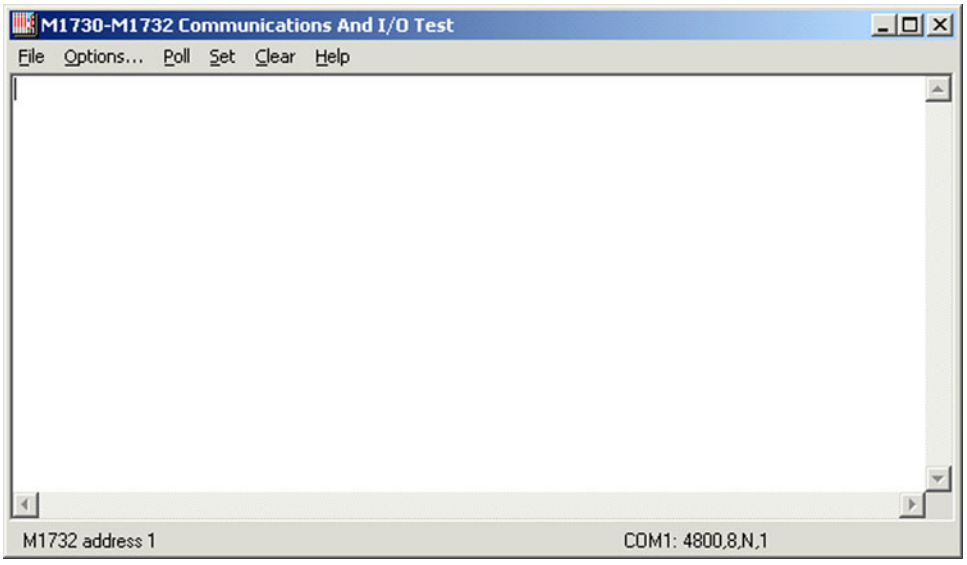


Figure 21. Communications and I/O Test Main Window

When connected to the Model 1730 controller, you will be able to test not only the controller but any RTU that communicates with that controller over the radio as well. If the Model 1730 has the MODBUS option, it must be configured to use the ULTRAc protocol so that it

will pass all messages received from RTUs through to the Communications And I/O Test program.

When connected to the Model 1732 RTU, you will be able to test only the I/O points on that particular RTU.

All functions of the program are accessed through the menus. The center of the main window is where messages received from the controller and/or RTUs are displayed. The bottom of the window shows the currently selected device type and address, and the communications port settings.

SETTING OPTIONS

Selecting Options from the main menu brings up the dialog shown in Figure 22.

In the Address field, put the address of the Controller or RTU that you want to test.

The Device field should specify the type of device you are testing. The choices include: 1730, 1732, 1708, and 1716.

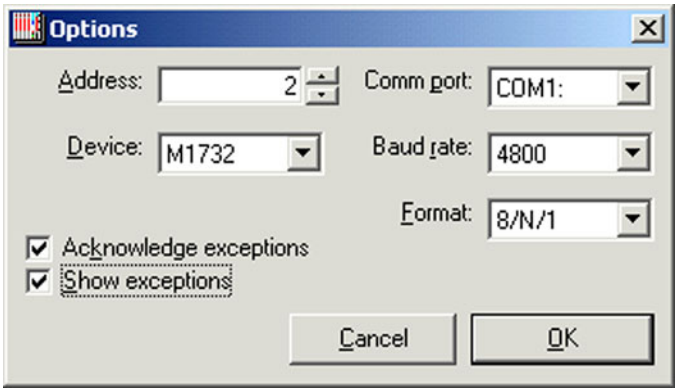


Figure 22. The Options Dialog Box

The Comm port, Baud rate and Format fields select and configure the RS232 communications port used to communicate with the device under test. You must select a port that is not in use by any other program.

The Acknowledge exceptions field should be checked if you want the test program to acknowledge exceptions reports received from the Model 1730 Controller and/or RTUs. If not acknowledged, the sender of the exception will keep sending the report, and eventually go into its communications fail state.

The Show exceptions field controls whether or not exception reports are shown on the screen. When this box is checked, exceptions reports received from any device will be displayed.

THE POLL MENU

The Poll selection in the main menu is used to poll the Controller or RTU for current I/O status, logic register values (Model 1732 RTU only) or hardware information.

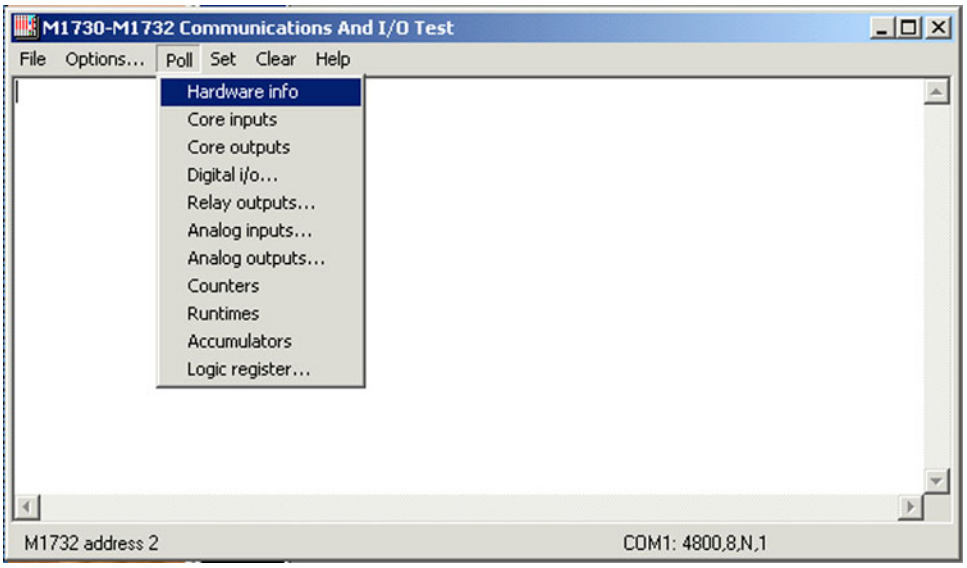


Figure 23. The Poll Menu

For menu items that end in an ellipsis (...), additional information such as the module or register number must be entered the before poll is sent. Examples of the dialogs for this are shown in Figure 24.

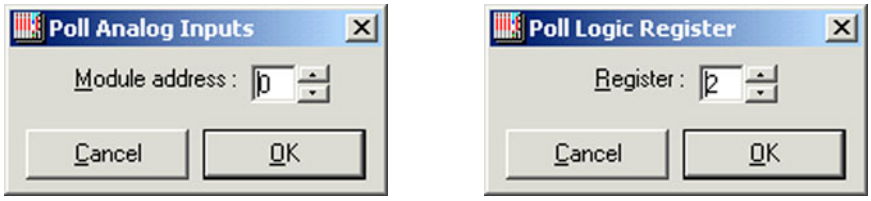


Figure 24. Entering Additional Polling Information

THE SET MENU

The Set option in the main menu is used to control outputs and change logic registers.

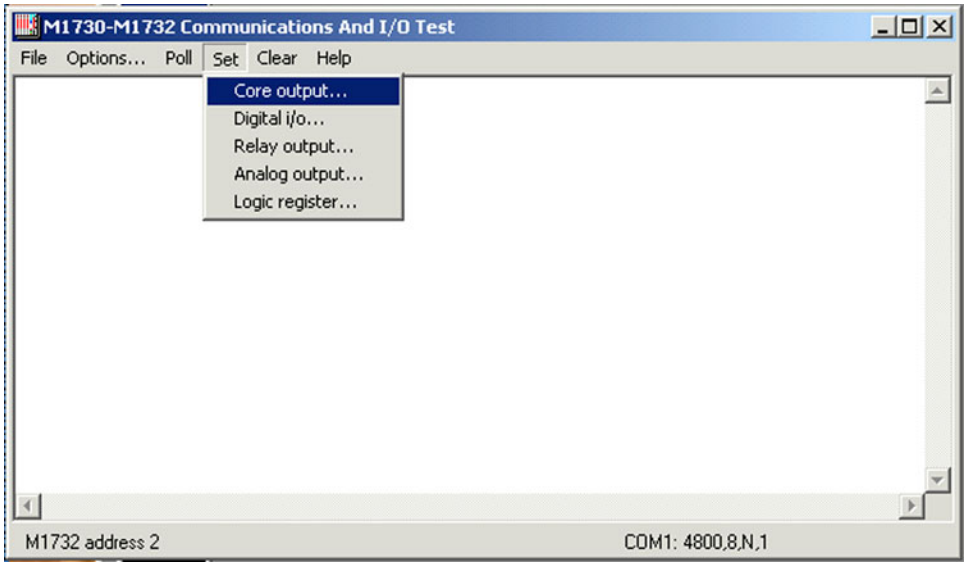


Figure 25. The Set Menu

When one of the Set menu items is selected, a dialog box always pops up requesting additional information such as the module number, output number and output value.

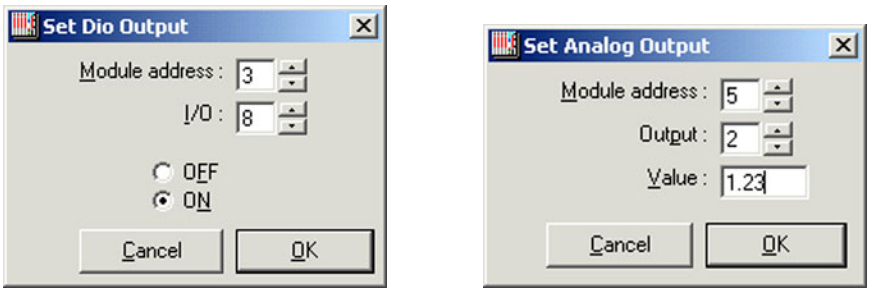


Figure 26. Entering Output Control Information

For setting logic registers, the register number, register type and new value are requested as shown in Figure 27.

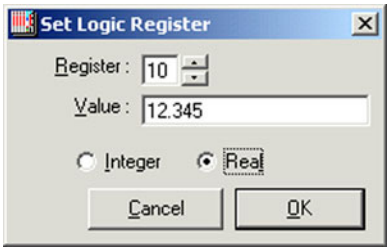


Figure 27. Setting a Logic Register

THE CLEAR MENU

The Clear menu provides options for clearing the message window and for clearing counters, runtimes and accumulators.

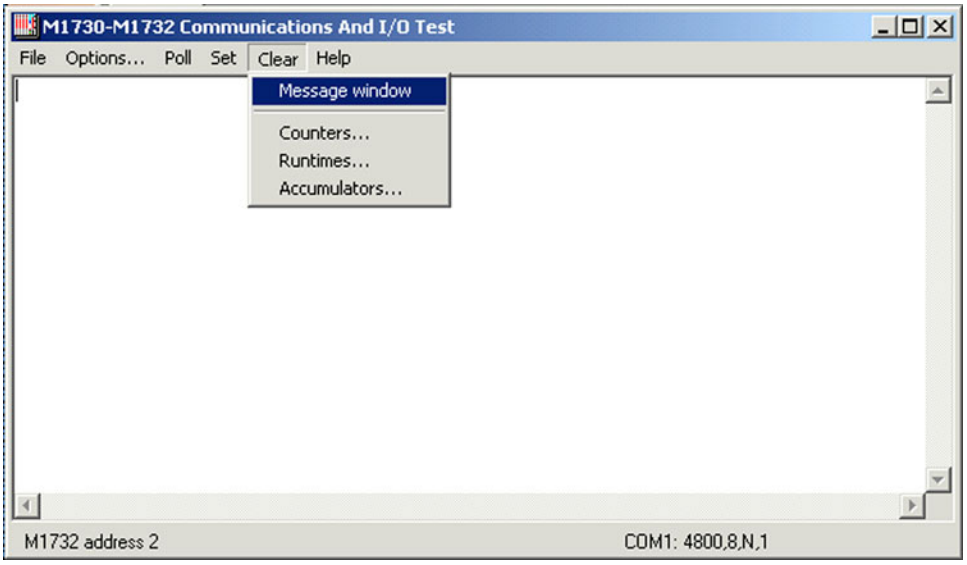


Figure 28. The Clear Menu

On the Model 1730 Controller and Model 1732 RTU, you can select one or more counters, runtimes or accumulators to clear at the same time. Figure 29 shows how this is done for counters.

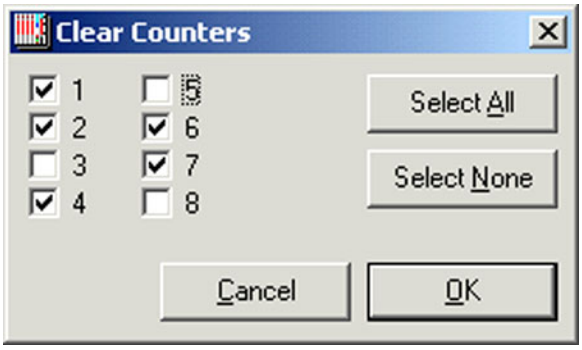


Figure 29. Specifying Which Counters to Clear

APPENDIX C — GLOSSARY

AC power module	The module that connects a device to an AC power source.
Accumulator	See analog input accumulator.
Acquisition timeout	The timeout for the first two steps of radio transmission: radio contention via the TXREQ signal and channel busy detect via the COR signal.
Activation delay	Time (measured in seconds) that a Core digital input or digital I/O must remain in the specified state to be considered as an alarm.
Address	See module address.
All call address	An additional address assigned to an RTU (besides its own device address) to which the RTU responds. All RTUs with the same All Call Address respond to messages containing this address.
Analog input accumulator	Analog input accumulators keep a running total of the analog input value over a period of time. They are often used to keep a running total of some flow through a system.
Analog input module	I/O module that connects its device to the outputs of analog field instrumentation and equipment to be monitored by the SCADA system. It reads analog voltage or current points.
Analog output module	I/O module that connects its device to equipment to be controlled by the SCADA system. The equipment must have proportional/analog controls. The module outputs analog voltage or current.
Autopolling	Data communications strategy where the SCADA master automatically sends queries for status to the RTUs.
Base station	Part of an RTU's Core properties that deal with communications and addresses.
Battery charger module	The module that provides power to a sealed lead-acid battery used for backup power.
Baud Rate	The rate of signal transitions for a given unit of time.

Binary format	A format to transfer information, generally consisting of ones and zeros. This is not intended to be a human-readable form.
Channel Busy Delay	The amount of time the radio channel must be available before the device will key up and transmit data.
Coil	From relay coil, now indicates a digital or relay output.
COM port	RS-232 serial communications port on a PC or Controller/RTU Core module.
Communications	See direct serial, phone modem, radio interface, or dedicated leased lines.
Communications failure	A breakdown in system communications. See exception reporting communications failure, polling communications failure, or RS-232 watchdog.
Communications failure mode	How the Controller handles an exception reporting communications failure: Do Nothing, Turn Outputs Off, or Turn On Core Module Relay. This property is set in the Configuration Utility and applies only to the Controller (the RTU uses local logic for handling exception report communications failures).
Communications Failure Wizard	A Configuration Utility programming tool for RTUs that assists in creating a program to automatically set all enabled outputs to a predetermined state if the RTU's communications link is lost.
Compile	To translate a computer program expressed in a high-order language into its machine language equivalent.
Configuration file	A database file that stores the settings and local logic for a device.
Configuration Utility	The RTU Configuration Utility is a Windows 95-based program used to configure the Model 1730 Controller and/or the Model 1732 RTU for use with the end user's specific application.
Controller	In this manual, the word "controller" refers to the device that interfaces between the computer controlling the SCADA system and a radio transceiver.
Controller Address	The device address of a Controller.

Core inputs	Digital inputs on the core module.
Core module	The required module for every device. It includes a CPU PCB and an I/O PCB.
Core outputs	Digital outputs and one relay output on the core module.
Core properties	General operational settings for a device, such as name, address, exception reporting, protocol, etc.
Counter	The counter value is a count of the number of times the digital input on the core module activates.
Data address exception	An error indication in the Modbus protocol that occurs when a query is sent to an illegal data address. It can also occur if the query addresses too many addresses at once.
Data logger	RTU function that triggers, acquires, stores, and retrieves information on its inputs and outputs.
Data Logging Overflow Strategy	How to handle an RTU's logger buffer overflow. The choices are DISCARD NEW RECORDS or OVERWRITE OLD RECORDS.
Data Logging Wizard	A programming tool that assists in creating a program to automatically control when input and output data is logged by an RTU.
Data value exception	An error indication in the Modbus protocol that occurs when an attempt is made to write an illegal data value to a location. For example, attempting to set an output with a maximum value of 5 to 10 volts.
Deactivation Delay	For an input, the amount of time that a Core digital input or digital I/O must remain in the specified state to *not* be considered as an alarm. For an output configured as momentary, the amount of time that the output stays on before automatically turning off.
Dedicated leased line	See leased line.
Device	In this manual, the word "device" refers to the Model 1730 Controller, the Model 1732 RTU, or other similar units.
Device address	The address of the core module in a device.

Device Name	User-entered name for an RTU or Controller.
Device password	Password required to change the configuration of an RTU or Controller.
Device Phone Number	Phone number required to reach the device via phone modem. This is only stored in the device configuration file; it is not stored in the device. This field is linked to the DEVICE PHONE NUMBER field on the Core Properties form.
Device Software & Version	The device's current software number and version. It is read from the device by the Configuration Utility.
Device Time Zone	Indicates the difference in time zones (in hours and minutes) between the device location (site) and the location of the PC running the SCADA control software.
Device Type	A configuration setting. A device can be either a Model 1730 Controller or a Model 1732 RTU.
Dialing Method	The signaling method used by telephones: tone or pulse.
Digital I/O module	I/O module that connects its device to equipment to be monitored or controlled by the SCADA system. The module inputs and outputs digital signals.
DIP switch	A small enclosure containing a row of on/off switches that are used in a manner similar to jumpers for configuring electronic hardware. The switch takes its name from the fact that it fits into the same hole pattern used for DIP-style integrated circuits. DIP switch packages typically come with either four or eight switches.
Direct serial communications	A method of communication where computers and devices are connected without a modem and use serial communication.
Enclosure	The general term used in this manual for the structure that the modules sit in. See NEMA enclosure or Z-Box.
Exception Report Channel	The communications method used by a device for exception reports to a Controller. The choices are: Radio, Phone, and Direct Serial.
Exception reporting	The ability of an RTU or Controller to report changes in I/O status to the master without being polled.

Exception reporting communications failure	An exception reporting communications failure occurs when the RTU or Controller sends an exception report a number of times (Maximum Retry Attempts + 1) and does not receive an acknowledgment.
Expansion bus connector	A connector on each module that connects the module to the expansion or extender cable.
Expansion cable	A communications cable that connects the core module to the communication and I/O modules.
Extender cable	A communications cable that connects additional modules to the basic set.
Form C relay	Relay with both normally open and normally closed contacts.
Group Call Address	An additional address assigned to an RTU (besides its own device address) to which the RTU responds. All RTUs with the same Group Call Address respond to messages with this address.
High Threshold	A value used with analog inputs or outputs to determine when to report an exception or log data.
Holding register	Modbus term for transferring special data, such as analog outputs or accumulators.
Hysteresis	For analog inputs, outputs, and accumulators, a method of preventing multiple exception reports or data log entries as the signal crosses the threshold value. The value represents fluctuations above or below the threshold that will not cause an exception report or data logging.
Inbound Address Offset	Parameter used for store and forward radio communications.
Inbound Address Range High	Parameter used for store and forward radio communications.
Inbound Address Range Low	Parameter used for store and forward radio communications.
Initial Retry Interval	The time interval to wait before attempting to establish communications through the Exception Report Channel after the first failure.

Input register	MODBUS term for transferring analog input data.
Inter-Packet Delay	The minimum delay between the time the radio is keyed down at the end of a transmission and the beginning of a key up sequence for the next transmission.
Interpreter	A method of computer programming where an intermediate language is used.
Key Down Delay	Delay between the end of a radio transmission and the time the radio is keyed down.
Key Up Delay	Delay between the time the radio is keyed up and the start of data transmission.
Leased line	Permanent wireline connection between Controller and an RTU. Also called "private line."
Local logic	User-programmable control program in an RTU.
Local logic wizard	Program in the Configuration Utility to assist the user in generating local logic programs.
Local RTU Status Storage	Storage of RTU I/O status in the Controller's memory between polls.
Logger	See data logger.
Logger data	The data stored in an RTU's data logger buffer.
Logic Editor	A simple text editor for local logic programs.
Low Threshold	A value used with analog inputs or outputs to determine when to report an exception or log data.
Master	General SCADA term for the central control (hardware and software) of the system. See Slave.
Max. Retry Attempts	The maximum number of retries before entering a Communications Failure alarm. A Communications Failure occurs when an exception has been sent "Maximum Retry Attempts + 1" without being acknowledged.
Max. Displayed Range	For analog inputs and outputs, the maximum possible value in the displayed units of measurement.

Max. Measured Range	For analog inputs and outputs, the maximum measured range that directly correlates to the Max. Displayed Range. The units of measurement used for this parameter (V or mA) depends on the selection made for the Analog Input/Output Mode.
Min. Displayed Range	For analog inputs and outputs, the minimum possible value in the displayed units of measurement.
Min. Measured Range	For analog inputs and outputs, the maximum measured range that directly correlates to the Min. Displayed Range. The units of measurement used for this parameter (V or mA) depends on the selection made for the Analog Input/Output Mode.
MODBUS	MODBUS is an industry-standard process-control protocol used to transfer commands and data.
Modem Detect Command	Command sent to the modem on power up or reset to try to detect the presence of the phone modem. The modem is expected to answer “OK”.
Modem Initialization String	This string is used to initialize the modem before a phone number is dialed.
Modem line	See phone line.
Module	Each device has one or more modules installed within it. These modules add different types of I/O or communications capability to the device.
Module address	The four or eight-bit number that identifies the module. The core module address is also called the device address.
Module Properties	When copying I/O modules, this refers to all properties (except for Name property) for the currently selected I/O module.
Modulo-10000 format	A method used in the MODBUS protocol to spread large data values across several registers. Each register holds a value between 0 and 9999. For example, the value 1234567890 would be spread across three separate registers containing the values 12, 3456, and 7890.

Mounting plates	Plates attached to a module's PCB. The plate has retained screws for fastening the module to the enclosure's backplane. Also refers to backplanes drilled for receiving the modules. Blank plates with retained screws can be used for mounting customer-supplied equipment. Blank backplanes can be used in customer-supplied enclosures.
Multiplier	For the Counter, this factor is used in converting the counter totals into the units selected by the user.
NEMA enclosure	An enclosure that meets National Electrical Manufacturers Association (NEMA) standards. The medium- and large-sized enclosures for the Model 1730/1732 are NEMA enclosures.
Offset	For the Counter, this offset is used in converting the counter totals into the units selected by the user.
Outbound Address Offset	Parameter used for store and forward radio communications.
Outbound Address Range High	Parameter used for store and forward radio communications.
Outbound Address Range Low	Parameter used for store and forward radio communications.
Percent Change Delay	A value used with analog inputs or outputs to determine when to report an exception or log data.
Percent Change Threshold	A value used with analog inputs or outputs to determine when to report an exception or log data.
Phone line	A dial-up phone line.
Phone modem module	A module that provides the interface between the RTU and a dial-up phone line.
PLC	Programmable logic controller. A small industrial device that originally replaced relay logic. Usually uses the MODBUS protocol for communications.
Poll Cycle Interval	For autopolling, this is the time between successive polling cycles, defined as the time between the end of one autopoll cycle and the start of the next.

Polled-only system	A SCADA system in which the master controls all communication. The RTUs only transmit in response to a poll (query) from the master.
Polling	Refers to the communications from the master to query the status of inputs on RTUs.
Polling communications failure	A polling communications failure occurs when an RTU does not receive a poll for a programmed period of time. A local logic program uses a built-in variable, LastPollTime, to detect this type of communications failure.
Power-Up Message	A message (e.g., product name, version number, etc.) sent by the device to its Port1 serial port on power-up.
Protocol	A set of conventions governing the format and timing of message exchange between two communications terminals.
Pump Rotation Wizard	A programming tool that assists in creating a local logic program used for maintaining a water tank (or other type of tank) at its optimum level by automatically controlling its filling pumps.
Query	A command from the master to the RTU to tell the RTU to respond with requested data or perform some action.
Radio interface module	A module that provides the interface between the device's core module and the radio transceiver. Also called "radio modem."
Radio modem	See radio interface module.
Real Time Clock	A battery-backed clock and calendar circuit built into a device. It keeps track of time even when power is off.
Relay Output Module	The module that connects a device to equipment to be controlled by the SCADA system. The equipment must have on/off controls.
Report by exception	See exception reporting.
Retry	For autopolling and exception reporting, an additional attempt to communicate with a device that fails to respond.
Retry Timeout	For autopolling, the timeout period begins at the end of the polling transmission from the Controller and determines when an RTU is considered to have failed to respond.

Rings to Answer	The number of rings to wait before letting the modem answer incoming calls.
RS-232	Standard for asynchronous serial data communications defining connectors and signal levels.
RS-232 Watchdog	Function in a Controller that looks for messages from the PC.
RS-232 Watchdog Mode	Action for the Controller to take if its RS-232 watchdog is triggered.
RS-232 Watchdog Timeout	A Controller monitors its RS-232 communications with the PC running the SCADA program. If the Controller does not see any messages in the set period of time, the SCADA program has failed.
RTU	Remote terminal unit. Usually a small stand-alone data acquisition and control device in the field that allows the central SCADA master to communicate with field instruments. It provides the interface between a radio transceiver or other communications link and the equipment being monitored and controlled. Its function is to control process equipment at the remote site, acquire data from the equipment, and transfer the data back to the central SCADA master. The Model 1732 is an RTU.
RTU Address	Device address of an RTU.
RTU Poll Interval	For autopolling, this represents the interval between receiving a response from the last RTU polled, and sending a poll to the next RTU in the sequence.
RTU Type	A configuration setting. An RTU can be a Model 1732, Model 1708, or Model 1716.
RTUBASIC	The language used for local logic programs.
Run-time	Run-time measurement is the running total of the time that a digital input on the core module is active.
SCADA	Supervisory control and data acquisition. General term for an industrial measurement, data gathering, and control system consisting of a central host or master, one or more field data gathering and control devices, called remote terminal units, and software used to monitor and control the remotely located field data gathering and control devices.

SCADA program	Software used to monitor and control remotely located field data gathering and control devices, e.g., LOOKOUT.
Scaling Factor	For accumulators, the numeric value associated with the time factor.
Script	An RTUBASIC program.
Serial communications	Communication method where data is transferred one bit at a time.
Slave	General SCADA term for the remote site data collection and control device (RTU). The slave reports to the master, the central control of the SCADA system.
Slot #	For Store and Forward radio transmissions, 10 slots or blocks of addresses can be assigned to the store and forward lookup table.
Software options	The current software options installed on the device. It is as read from the device by the Configuration Utility and displayed in the Core Properties dialog box.
Source file	The human readable form of a computer program.
Store and forward	The ability of an RTU to receive messages from the Controller and resend the message to another RTU and vice versa.
Stored status	RTU status stored in a Controller and used to build responses to MODBUS protocol queries.
Time Factor	For accumulators, the time factor is used to adjust the samples-per-second accumulation to the custom values.
Z-Box	The Zetron box is the smallest enclosure size for the Model 1730/1732.

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